INTEGRATION OF THE DISASTER RISK REDUCTION (DRR) AND DISASTER RESILIENCE MECHANISMS INTO THE GREEN BUILDING RATING SYSTEMS - CASE STUDY ON THE GREEN SL RATING SYSTEM OF SRI LANKA

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Declaration of the Candidate & Supervisors

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Abstract

The rapid growth of global human population necessitates the facilitation of increased number of buildings and other infrastructure. Primarily in economically developing nations, these buildings are designed only complying with local level regulations and standards which are outdated and not carrying allowance for disaster risk reduction and climate changes such as global warming. In the context of Sri Lanka, unplanned developments and expansions due to urbanization has made the community and their assests and resources vulnerable to natural hazards like floods, landslides, tsunami, droughts, coastal erosion and cyclones. Out of them, floods, landslides, heavy winds and Tsunamis have caused the highest number of damages to buildings and loss of human lives during the period of 1965 to 2019 and hence can be considered as significant in providing action.

Since anthropogenic natural hazards have kicked off to occur more frequently, it is vital to erect buildings, especially community shelters, in a way that they can withstand strains and pressures that will be imposed by changing future trends. Striving to achieve its vision, the Green Building Council of Sri Lanka (GBCSL) is playing a commendable role in maximizing Sri Lanka's greener practices and sustainability through the development of green rating tools for buildings and infrastructure, recognition of green materials to be used as construction materials and conducting professional training programs, green talks, workshops and many CSR activities. It has inculcated sustainability and resilience in their rating systems and practices, through enhancing the usage of locally manufactured and less energy consumed material and reducing resource and energy consumption in buildings, it has not yet been properly recognized the need to inculcate the Disaster Risk Reduction (DRR) mechanisms in to their rating systems. Therefore, to ensure an economically viable, environmentally-friendly and socially recognized growth in Sri Lanka, it's high time that the sustainable disaster risk reduction and mitigation measures are incorporated in the design, construct and operation phases of buildings.

Thus, this study was carried out to incorporate the DRR and disaster resilience structural and non-structural mechanisms for floods, landslides and heavy winds into the existing categories of the rating tools for buildings, cities and transportation infrastructure of the GREEN SL Rating System for Built Environment in Sri Lanka in transforming the existing construction industry of Sri Lanka into a disaster resilient and a sustainable one.

Key Words: Natural Hazards; Disaster Risk Reduction; Green Buildings; Disaster Resilient Buildings

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INTRODUCTION

1.1 Context

Catastrophic disasters induced by natural and man-made hazards are inevitable but taking necessary prevention and resilient measures will help to reduce the social, environmental and economical adverse impacts immensely. Engineering can be seen as an art of application the science, technology and mathematics with a blend of social science in solving the problems aroused in the built environment. Engineers find practical solutions and figure out how things work while designing, evaluating, developing, testing, modifying, installing, inspecting and maintaining a wide variety of systems, processes and products [1].

When we look in to the global risk profile, in the 2019 Global Risk Report produced by the World Economic Forum lists the world risks under five main categories, namely; Economic, Environmental, Geopolitical, Societal and Technological [2]. The risks, rated based on their likelihoods and impacts are illustrated in Figure 2. When analyzing the risks along the above five categories, it can be clearly observed that at the beginning of the last decade how economic risks have subjugated and how environmental risks have started having an increasing trend by the end of the same decade in both impact and likelihood. When we zoom in to the category of environmental risks, the related risks are; Extreme weather events, Failure of climate change mitigation and adaptation, natural hazards. If we observe in another view as shown in Figure 1, the risks have been plotted against impact and likelihood. It clearly shows that the highest or top three values against both aspects have been achieved by environmental risks, extreme weather occurrences, failure of climate change adaptation and mitigation and natural hazards. These data indicate that the domination of the world risk matrix has moved on to the environmental risks presently. Hence this is an eye opener which highlights the necessity to address the environmental risks and managing them properly.

World Health Organization (WHO) declares that, in a global context, the number of people killed by the natural disasters exceeds 90,000 and nearly 160 million people are affected by them annually. Natural disasters such as floods, droughts, earthquakes, tsunamis, landslides, hurricanes, volcanic eruptions, wildfires and heat waves not only cause immediate destructions to the physical, biological and social environment of the community, but also impose a long-term threat on the health and well-being of its people. [3].

Also, the report ‘Economic losses, Poverty and Disaster - 1998 and 2017’, published by United Nations system for Disaster Risk Reduction (UNISDR) highlights that geophysical and climate-related disasters have killed around 1.3 million people and made another 4.4 billion people injured, disabled, displaced or in need of assistance during the period of 1998 and 2017. While the majority of fatalities occurred due to geophysical events, 91% of all disasters were caused by extreme weather events like floods, droughts, heatwaves and storms. During 1998-2017, the countries hit by natural disasters have gone through direct economic losses valued at US$ 2,908 billion. Out of that US$ 2,245 billion or 77% of the total has been resulted due to climate-related disasters. From that, 68% (US$ 895 billion) has been reported between 1978 and 1997. That is a rise of losses by 151% between these two 20-year periods due to extreme weather events.[4].

The Munich Re NatCatSERVICE, reports about 850 natural hazard induced disasters occurred in 2018 only. Out of them, 5% was reported to be Geophysical disasters such as earthquakes, volcanic eruptions and tsunamis, 42%, to be storms, 46% to be floods, flash floods and landslides and 7% to be wildfire, cold and heat. 43% of all the disasters have been reported from Asia, 20% from North America, 14% from Europe, 13% from Africa and 10% from other regions. [5]

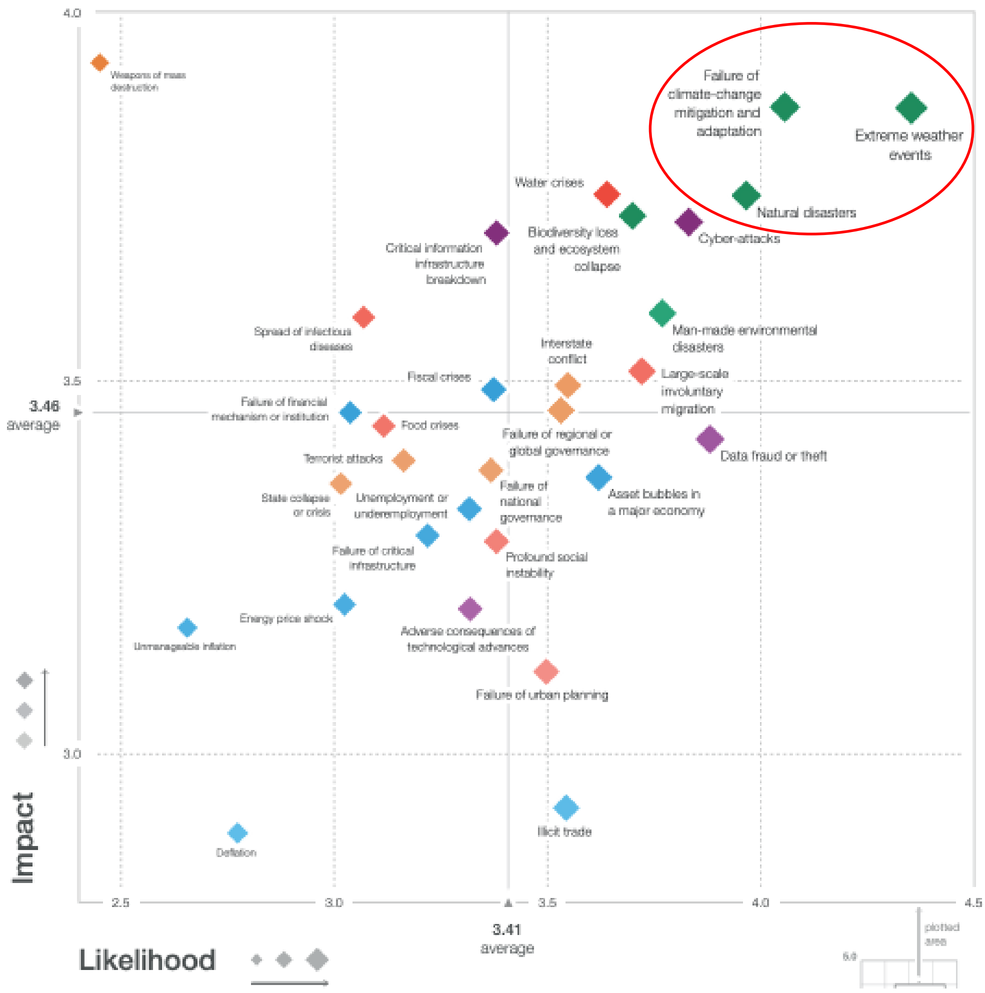

Figure 1: Variation of five risk categories based on impact and likelihood [2]

Figure 2: Global Risks from 2009 to 2019 (Source: World Economic Forum Risk Perception Survey 2018-2019, [2])

When referring to Sri Lanka, because of the fact that it is a tropical country located near the equator between 5°and 10°N, and 79° and 82°E it often meets with frequent rainfalls and also increased temperaturues at times. throughout the year. Also, it is inevitably weather sensitive to the changing activities in the Bay of Bengal. Sri Lanka is located in south west monsoon region where northern and eastern island are considered to be dry zones because of the range of mountains which act as a barrier of the central highland. The Wet Zone of Sri Lanka usually receives over 5000 mm of annual rainfall. Sri Lanka's climate is governed by the Southwest (May - September) and Northeast (December – February) monsoons and two inter monsoon seasons also affect it. (First - March to April and Second – October to November) Behavioral patterns of the Bay of Bengal widely affect the changes in wind patterns and changes in durations of occurrence. [6].

By Germanwatch Global climate index, in 2018, Sri Lanka was listed as the 2nd highest nation who was adversely affected from extreme weather events. Majority of Sri Lankan natural hazards are identified to be hydro-meteorological hazards like floods, high winds, landslides, etc. of which floods are most critical. River floods, urban and flash floods, landslides, cyclones, wildfires are considered to be the main hazards with high risk and coastal erosion, tsunami and droughts are considered to be of medium risk [7]. Out of all, floods and associated landslides are considered to be the most common type of natural hazards effective for Sri Lanka. Cyclones, droughts, and tsunamis are considered to be severe hazards though their occurrences are of less frequency [7]. Since 1965, 224,760 houses have been damaged due to floods while 128,705 houses have been affected severely from high winds and, 105,293 houses have been damaged due to tsunami and 14,761 houses from landslides [8] as tabulated in table 1. It shows that, floods have been the main catastrophe that affected the greatest number of families in Sri Lanka throughout the last four decades and it will be worse in future due to the sky rocketing trends of flood profile. In the capital city, Colombo, the rapid economic growth and alterations in land use patterns aggravate flood risk. Therefore, flood risk reduction is taken into consideration by relevant authorities taking extenuation actions to save lives and properties currently [9]. In 2016 total affected people from the May flood were 340,000 whereas in 2017 it was 630,000. When looking in to 2018, the total flood impact for people was around 45,680, during the first week of May itself [10].

The Indian Ocean Tsunami (IOT) occurred in 2004 is recognized to be one of the most fatal coastal disasters in recent history which caused over two hundred and thirty thousand (230,000) deaths across more than 15 countries in both Asian and African regions [10]. The earthquake that gave rise to the 2004 IOT had a magnitude of Mw 9.3. marking its magnitude as the largest earthquake since the 1964 earthquake [11]. At least four-fifths of the coastal belt of Sri Lanka was affected from this Tsunami which placed Sri Lanka among top few nations that were severely affected. In Sri Lanka, figures show, 29,729 human passing's, 889,175 displaced people and over 79,100 devastated houses due to 2004 IOT [12], [13].

Table 1: Summary of Deaths, Houses Destroyed and Damaged, Affected Victims and Local Losses from Main Disasters Occurred in Sri Lanka (1965 - 2019) [8]

Hazard / disaster	Number of Deaths	Houses Destroyed	Houses Damaged	Number of Affected Victims	Local Losses ($)
Animal attack	1,002	197	7,715	80,207	NE
Coastline & coastal erosion	0	153	437	4,137	NE
Collapse of building	15	0	1	12	NE
Collapse of Garbage fill	32	60	22	1,782	NE
Cyclone	846	18,208	111,565	1,375,005	NE
Cyclone & flood	9	13,178	37,371	319,128	NE
Drought	0	0	0	20,725,949	NE
Earth slip	10	56	168	3,043	NE
Epidemic	368	0	0	572,644	NE
Explosion	1	161	346	7,952	NE
Fire	108	2,078	1,043	16,489	7,700,000
Flash flood	6	72	684	8,812	NE
Flood	707	55,003	186,548	15,068,593	378,500
Forest fire	1	16	19	198	NE
Heavy rains	37	689	7,583	780,213	NE
Landslide	1,077	2,900	12,026	291,964	1,038,000
Lightning	549	37	595	4,014	NE
Strong wind	211	7,693	104,548	731,571	1,077,900
Tornado	0	58	277	910	NE
Tsunami	30,959	57,085	48,069	970,705	16,130,000
Urban flood	0	0	0	155	NE

*NE = Not Estimated

When we look into the economic losses caused due to natural disasters, it is an average annual loss of $380 million which is averagely 3% of total government expenditure, according to World Bank estimates. The distribution of nationally reported economic losses due to main natural hazards occurred during 1990 to 2014 in Sri Lanka is shown in Figure 3. Frequency and the seriousness of impact of hydro-meteorological hazards are to be more triggered by the climatic action. The records of Disaster Management Center (DMC) of Sri Lanka and UNISDR state that floods are the most frequent, and the disaster which destroyed the greatest number of buildings during the period of 1965 to 2019 in Sri Lanka [7].

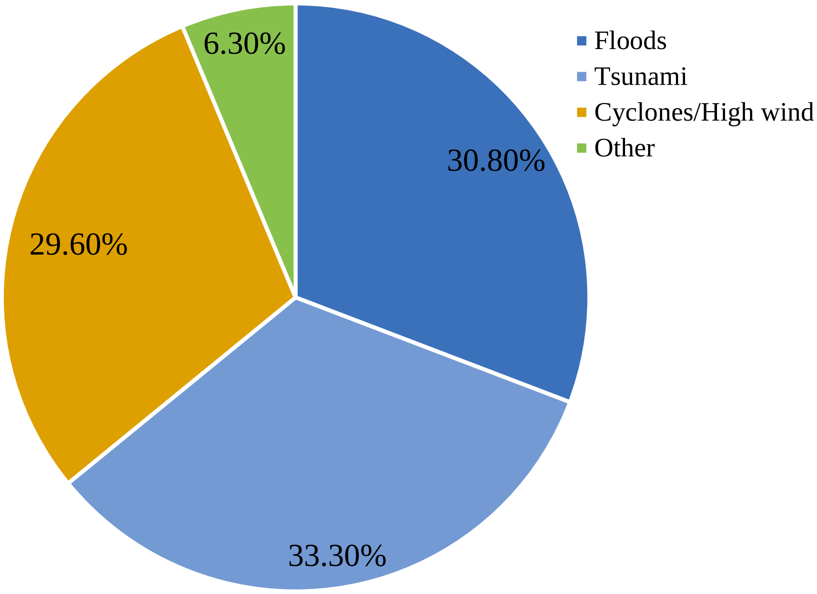

Figure 3: Nationally Reported Economic Losses (1990-2014) [7]

This sky rocketing trend of catastrophic losses and destructions occurred due to natural hazards are mainly due to the rapid rate of urban growth and unplanned urbanization with increased dependence on complex infrastructure, buildings and infrastructure of poor quality, and the adverse impacts of climate change [14]. The necessity of disaster resilient building codes for Sri Lanka has been highlighted for the purpose of minimizing disaster risk and vulnerability. [15]. But investigations in 2004 showed that the use of these codes are mainly limited to the urban areas in Sri Lanka [16]. A study carried out by the AIT in 2012 has examined on integrating of DRR measures into the national building codes of Sri Lanka for wind, rain and flood and landslides [17]. It manifests that the Sri Lankan building codes do not emphasize measures on landslide resistance and flood situations and impact of wind hazards are also discretionary while on the other hand, a detailed and comprehensive disaster resilient building code could not be found yet in Sri Lanka, which is an essential need to be met in transforming the existing construction industry inti a sustainable one. In 2013, ADPC was able to find that the present housing stock in the country has a deficiency around 600,000 units and from the available units 915,000 units are sub-standard and require urgent improvement or rehabilitation [17]. Moreover, the existing housing stock also possesses a vulnerability to natural hazards such as floods, landslides, cyclones and domestic fires, mainly due to issues such as land use, land tenure, lack of availability of land, land management and a lack of infrastructural facilities. These clues and facts will impede the efforts to emphasis and enhance disaster resilience in the built environment that consists of roads, railways, hospitals, schools, treatment plants, power generation plants and buildings of single storied to high rise commercial and residential developments.

The construction sector which facilitates the buildings and infrastructure needs of a society has high strategic importance for a country [7]. The value chain of construction consists of a wide range of economic activities, starting from the extraction of raw materials up to the manufacturing and distribution of construction products, their maintenance, renovation and demolition, as well as the recycling of construction and demolition waste.

The built environment has such an important role in serving human activities that whenever its elements are destroyed, the society's economical functionality is affected [19]. Disasters can impede a person's ability to eliminate poverty. If there are protective elements in the built environment, they will help to reduce the hazards, but after a disaster the lost critical infrastructures will lead to increased risk of future hazards. Because of the inherent and local nature of the built environment, generic solutions cannot be applied everywhere. Building codes – the standard to which architecture is constructed – have the potential to save millions of lives, so long as they are properly enforced [20]. Sadly, this is a rarity at present – from California to Indonesia and Sri Lanka, building codes are not uniformly or properly applied. Buildings that could otherwise stand up to major hazards, are located in highly exposed areas, end up destroyed or being inundated. Ideally, new buildings in high-risk areas are designed to withstand damages due to disasters. Older buildings, which cannot just be knocked down and replaced, should be retrofitted with hazard-proofing structures. A study shows that $6 can be saved in property damages, disturbance to businesses and health issues, for every dollar the government spends in making the buildings more disaster resilient. Also, it reveals that $4 can be saved for every $1 spent to improve building codes and make structures more hazard-resilient in future, [21]. Also, it concludes that, over the next 75 years, this could prevent over 600 deaths, 1 million injuries and 4,000 cases of mental health issues associated with post-trauma of disasters.

As discussed before there is an unfilled gap in the GREENSL® Rating System for Built Environment where it could incorporate disaster risk reduction mechanisms. Even a platinum rated green building constructed in a sustainable manner is still prone to damages from natural disasters if proper DRR measures have not been incorporated. There are two types of DRR mechanisms for hazard preparation and mitigation namely structural (hard) and non-structural (soft) measures. Nonstructural measures include proper regulation, awareness and early warning for disasters and structural measures include adding structural components to buildings and cities to prevent the impacts from natural disasters. This research also brings out hard and soft DRR mechanisms for floods, landslides and heavy winds which will be adopted to the GREENSL® Rating System for Built Environment. Therefore, nationally and internationally accepted and adopted structural and non-structural DRR measures are recognized and adopted in a manner which is applicable to Sri Lankan context for hazard resistant buildings, in this research thesis. There is also a need to rethink on how to develop practices and skills across Sri Lanka's built environment sector to meet the challenges that arise with disaster risk and climate change, and to ensure economic feasibility for land and real estate firms while serving for social needs and transforming the built environment into a sustainable and safer one resilient to disasters.

With the above context understanding we can define the research gap and identify the research objectives and define methodology to achieve the objectives.

1.2 Research Gap

From the above context understanding we can identify four key observations which are considered to be major gaps in this research area.

First is that the natural hazard induced disasters due to floods, landslides and heavy winds are a major risk, which is growing in impact and likelihood in Sri Lanka.

Second is that though GBCSL has inculcated sustainability and resilience in their rating systems and practices, through enhancing the usage of locally manufactured and less energy consumed material and reducing resource and energy consumption in buildings, it has not yet been properly recognized the need to inculcate the DRR mechanisms in to their rating systems.

Third is that even though a construction is platinum rated green building with many greener and sustainable concepts incorporated, it cannot be considered as sustainable if it is unable to withstand against natural disasters.

Forth observation is that, although many best practiced guidelines and manuals have been developed by National Building Research Organization (NBRO) and Society of Structural Engineers Sri Lanka (SSESL) etc, most of the housing and small-scale buildings are constructed without referring these manuals or proper design guidelines. Therefore, a detailed and comprehensive building code for disaster resilience could not be found in Sri Lanka.

In this regard the research study was based to address the above research gaps through developing a disaster resilient and a sustainable green rating systems for Sri Lanka.

1.3 Research scope

Understanding the existing disaster risk and vulnerable hazards and their conditions were the preliminary requirements in addressing the above research gaps. For that the overall picture of hazards, their adverse impacts, most vulnerable hazards and disaster risk induced through each of the hazard for Sri Lanka were identified and understood. It was observed that the floods, landslides and heavy winds are the most frequent, highly vulnerable and which have caused significant building damages around the country. Hence these three hazards were identified as the 1st boundary for research study.

Given the fact that the research work is focused on developing a disaster resilient rating system, the next boundary to be identified was a community asset. Out of community assets of, population, natural environment, built environment and economy, built environment was chosen as the second boundary to carry out the research study. Within the built environment the major focus was given to the buildings, transportation infrastructure and the cities focusing the GREEN^{SL}® Rating System for Built Environment for buildings, transportation infrastructure and cities tools.

The next boundary for the research was defined based on the information sources. The main information sources selected for the study were global frameworks such as Millennium declaration, Sendai framework and Hyogo framework and local guidelines and frameworks such as National Building Research Organization (NBRO) guidelines, frameworks by Society of Structural Engineers Sri Lanka (SSESL), Building Codes & guidelines, frameworks and hazard zonation maps developed by Disaster Management Center (DMC) Sri Lanka, etc.

In developing a disaster resilient green rating tool for Sri Lanka with structural as well as non-structural DRR mechanisms, the next boundary to be defined was based on green rating tools. Out of the seventy-member green building councils of World Green Building Council (WGBC) and other green building councils, five rating tools from four countries were selected based on the factors of, usage and popularity of the tools, vulnerability level of the counties for natural hazards and their world risk index as shown in Figure 4. Countries with very high (dark pink) and high (moderate pink) risk indexes were highly focused in green rating tool selection. After a through observation of all the above-mentioned factors LEED and RELi of Green Building Council of United States, CASEE of Japanese Green Building Council, GREENSHIP of Green Building Council of Indonesia and BERDE of Green Building Council of Philippines were selected.

Hence the research work is scoped to the above selected hazards, community assets and tools and frameworks based on the timeline and research work.

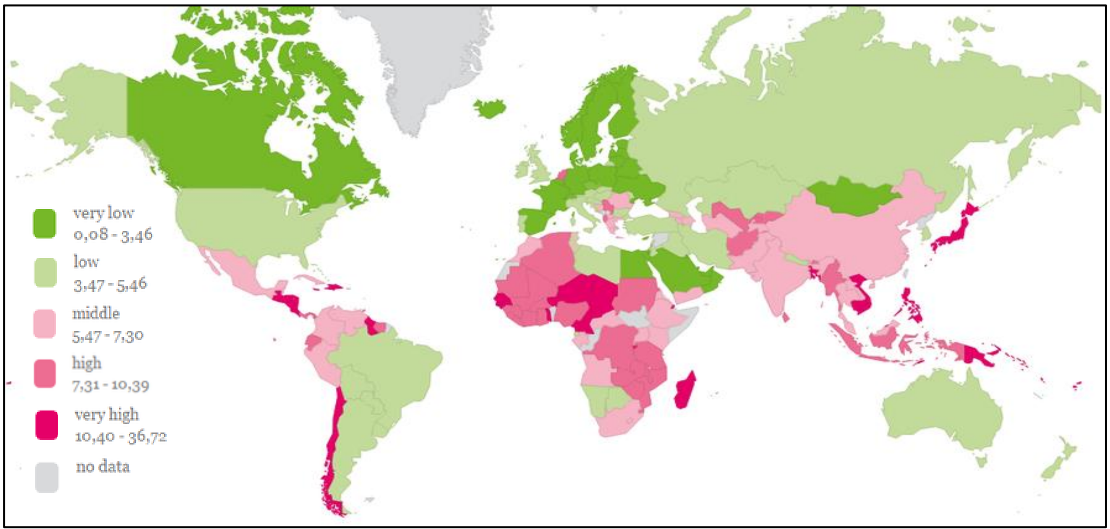

Figure 4: World Risk Index (2016) by IRDR|http://www.irdrinternational.org

1.4 Research Question

Above research gap and scope can conclude with four major major research questions as below.

1. What are the major natural hazards where Sri Lankan community assets are mostly vulnerable into?
2. Does Sri Lanka have a detailed and a comprehensive building code addressing DRR and disaster resilience measures?
3. Does the existing building tool of the GREEN$^{SL®}$ Rating System for Built Environment address the required DRR and disaster resilience measures?
4. Do the green buildings certify by Green Building Council of Sri Lanka are truly sustainable?

1.5 Objectives

There are three objectives defined to address the above identified research gaps.

1. Identifying structural and non-structural DRR mechanisms for floods, landslides and heavy winds aligned with the local and global frameworks for DRR and disaster resilience to deepen the integration of DRR and disaster resilience with the GREEN$^{SL®}$ Rating System.
2. Developing a set of guidelines using the identified structural and non-structural DRR mechanisms which can be incorporated into the GREEN$^{SL®}$ Rating System for Built Environment.
3. Incorporating the developed disaster mitigation and preparation guidelines into the GREENSL$^{®}$ Rating System for Built Environment through improvements to the sub-categories under main 8 categories.

2 LITERATURE REVIEW

Under the literature review, following aspects are discussed which is used and incorporated into the research study in developing a disaster resilient GREENSL® Rating Systems for Built Environment.

- Introduction to Disaster Risk Reduction (DRR) & Disaster Management
- Global Frameworks for Disaster Risk Reduction (DRR)
- Green Building Councils and Green Rating Systems
- GREENSL® Rating Systems for Built Environment
- Disaster Risk Reduction (DRR) Mechanisms and Disaster Resilient Local Guidelines

2.1 Introduction to Disaster Risk Reduction & Disaster Management

Before we go deep into DRR or disaster management and their guidelines, let us identify the term 'risk' and its background. This chapter will be an introduction to the next 4 sections of the literature review.

In 1991, C.B. Chapman defined risk as a measure which depends on hazard and vulnerability. Also, he defined vulnerability as a parameter which provides space for the exposed system while the space provided for mitigation measures is not observed as well.

$$Risk = Hazard \times Vulnerability$$

Equation 1: Risk Equation by Chapman [22]

Chapman illustrates hazard as a potential risk in its untreated form, which includes the impact on its highest level and allows the probability parameter to be included in the hazard parameter [22].

The book on "Index for Risk Management" by Greove, Poliansek and Vernaccini in 2015 defines the risk as a multiplication of three parameters [23].

$$Risk = Hazard \times Vulnerability \times Deficiencies\ in\ Preparedness$$

Equation 2: Risk Equation by Greove [23]

'Deficiencies in preparedness' is a parameter which was introduced to imply mitigation measures in the risk analysis. What is meant by the parameter here as identified by Rafetry in 2003 is that, reciprocal of capacity. Rafetry also introduces risk as a measure of three parameters, including capacity instead of deficiencies in preparedness [24].

$$Rsik = \frac{Hazard \times Vulnerability}{Capacity}$$

Equation 3: Risk Equation by Rafetry [24]

According to the Equation 3, Hazard and vulnerability measures illustrates the exposed nature and the availability of hazards for a particular system and capacity measure indicates the risk mitigation and the absorption capacity of that same system.

Disaster risk reduction (DRR) is a systematic approach in recognizing, evaluating and minimizing the disaster risks in an identified system. It aims to reduce socio-economic vulnerabilities that may occur due to disasters as well as minimizing the environmental and other hazards that may create as a result. Disasters are often followed by natural hazards. The severity of a disaster depends on the acuteness of the impact caused by the hazard on society, economy and the environment. Reducing the exposure of people and property to hazards, proper management and utilization of land and the built environment, and increasing the preparedness for adverse impacts are all examples of disaster risk reduction. DRR not only consists of disciplines such as disaster management, disaster mitigation and disaster preparedness, but DRR is also an aspect of sustainable development. Since unhealthy development policies will increase disaster risk and disaster losses, DRR has to be involved in regulations which affect every part of society and which beneficiate the professional and private sector stake holders and assets [26].

UNISDR defined disaster as a serious disruption which disturbs a system of community and their assets. Disasters create severe impacts to human life, infrastructure and environment where the community system's own resources are not enough to cope up with [27]. Disasters are categorized in numerous ways such as natural hazard induced disasters and man-made disasters, etc. Also, another categorization of disasters is; Geophysical, Hydrological, Climatological, Meteorological and Biological etc. Disaster management comprises of number of stages as illustrated in the Figure 5 [28]. These disaster management stages or steps can be integrated into a cycle, disaster management cycle due to the repetitive behavior and continuous improvements in its steps, pre-disaster, disaster and the post disaster. Disaster risk reduction and disaster risk management comes under the stage of pre disaster whereas rescue and relief work under the response stage. Also under the post disaster stage, rehabilitation and future disaster risk management activities can be listed [27]. Disaster management strategies are developed based on the two concepts of DRR and disaster resilience. Reducing the vulnerability to hazards and mitigation of risk by management of resources efficiently will address the goal of risk reduction [27].

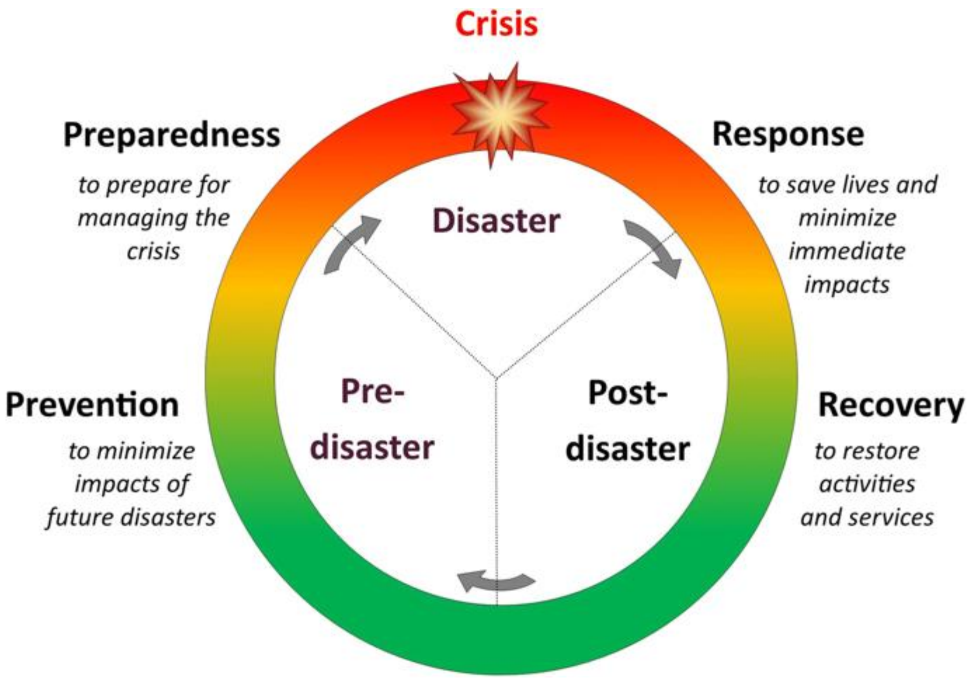

Figure 5: Disaster Management Cycle [28]

2.2 Global Frameworks for Disaster Risk Reduction

Disaster risk reduction is an inborn segment of sustainable development [29]. However, the construction of a giant fortress against the elements will not ensure that the building will be well performing in terms of energy or water efficiency; In a similar manner, even a green building will not be able withstand severe natural hazards and extreme weather events [30]. These two aspects cross each other in the new emerging trend of "high-performing" buildings. High-performing buildings are a type of buildings which consider both green building concepts and safety and security aspects as well. Communities who are interested in their own resilience might also be interested to apply resilient in green buildings as well which also aims to use renewable energy sources, resource efficiency by reducing, reusing and recycling, and water management.

The disaster risk framework from Intergovernmental Panel on Climate Change (IPCC) presented the cyclic relationship of all variables involved especially for those of disaster risk reduction and climate change adaptation. Climate change and the continuous boom of world population drive urbanization while increasing pressure and strain on the existing built environment and increase the demand to build for more [31]. Unceasing developments intensify anthropogenic hazards through greenhouse gas emissions, mainly although these developments comply with local and national codes, these codes are not addressing future trends of climate change. Current methods on infrastructure development to help mitigate disaster risks from flooding and earthquakes though some of them function their purpose, inherently exacerbate anthropogenic hazards through the complete disregard for sustainable and resilient designs and construction methodologies; bringing us back to step one. This cyclic loop is what is presented in the Risk Conceptual Framework from IPCC as shown in Figure 6. Together with other sectors, this cyclic loop has been acknowledged by the design and construction industry which has worked on numerous legislations and rating systems to promote sustainable designs and construction methodologies.

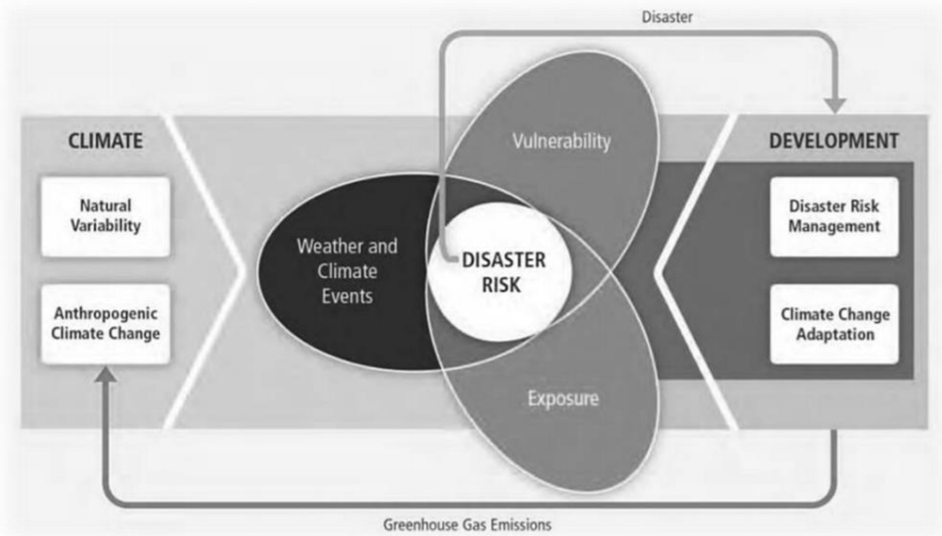

Figure 6: Risk Conceptual Framework proposed by the IPCC WGII-AR5 (2014)

In 2005, the Sendai Framework for Disaster Risk Reduction 2015–2030 was introduced by 187 UN states to tackle increasing losses due to disasters, including Sri Lanka, which encourages measures for minimizing disaster risk which are multi-hazard as well as multisectoral, accessible and inclusive to be effective and efficient. This recognizes that it is essential that the private sector work together with other stakeholders to make more opportunities collaboratively and that the businesses should incorporate disaster risk in their practices of management. Also, it highlights the need of promoting the integration of knowledge regarding disaster preparedness, mitigation, preventive measures, response, recovery and rehabilitation, to the professional and educational trainings. In 2015 three international policy frameworks were established namely Sendai Framework for Disaster Risk Reduction 2015 - 30 (March 2015), the Sustainable Development Goals (September 2015; SDGs) and the Climate Change Agreement (December 2015: COP21). Before the development and implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030, Millennium Declaration (2000) and Hyogo Framework for Action (2005 - 2015) were the frameworks and guidelines which were used by the countries to manage and prepare for the natural hazards and the induced disaster risks.

On 8th of September 2000, at the headquarters of the United Nations in New York after a three-day Millennium Summit, 60 goals were adopted by the UN General Assembly related to development, human rights, peace, environment, hunger and poverty. Africa; and the United Nations which is called Millennium Declaration

(Resolution 55/2) [32]. Those leaders identified that the major challenge of that era was to make it a certain that globalization becomes a positive force acknowledging about its unequally shared benefits and costs. The Declaration was developed based on global policies and measures while addressing the needs of developing countries and economies. It had set objectives for an international agenda for 21st century and also deadlines for many collective actions. The Summit Declaration highlighted the freedom, solidarity, equality (among individuals and nations), respect and tolerance for nature and shared responsibility to international relations for the twenty-first century as fundamental six values [33]. The Declaration consists of 32 paragraphs under 8 chapters which are namely, Development and poverty eradication, Values and principles, Security and disarmament, Protecting the vulnerable, Peace, Preserving the common environment, Democracy, Human rights and ethical governance, Strengthening the United Nations and concerns of the special needs of Africa [34].

Millennium Declaration was a framework which was developed in order to address the burning global issues of the twenty-first century as a whole. With the increasing trends of natural disasters day by day, the need of a disaster risk specified and focused framework became a vital necessity and Millennium Declaration was not sufficient to meet the challenges caused by natural disasters. Therefore, in 2005, a union of 168 Governments adopted a plan of 10 years to make a safer world from natural hazards at the World Conference on Disaster Reduction (WCDRR), held in Kobe, Hyogo, Japan. It was the Hyogo Framework for Action (HFA) which lead the communities and their nations to become more resistant to hazards. It was also been recognized as the global blueprint for DRR efforts between the period of 2005 to 2015. Its primary goal was to significantly minimize disaster losses by 2015, not only deaths but also the loss of social, economic, and environmental assets of nations. HFA progress reports bring out national, and regional progress in the implementation of DRR measures and developing baselines on levels of progress achieved in the implementation of the HFA's five priorities for action as listed below [34],

- Priority 1: Making DRR a policy priority, institutional strengthening
- Priority 2: Risk assessment and early warning systems
- Priority 3: Education, information and public awareness
- Priority 4: Reducing underlying risk factors
- Priority 5: Preparedness for effective response

When reaching the year 2015, almost at the end of the decade; 2005 -2015 which the HFA reached a level where effectiveness was reduced, the need for a revision or a new framework was seen to be essential with the rapid change of global risk profile. The World Conference on Disaster Risk Reduction (WCDRR) that was held in March 2015 in the city of Sendai, Miyagi Prefecture, Japan where UN Member States gathered together and developed the Sendai Framework for Disaster Risk Reduction 2015-2030, a forward-looking, action-oriented and precise framework for DRR. The Sendai

Framework for Disaster Risk Reduction 2015-2030 was established after the Hyogo Framework for Action and the first main agreement after 2015 development agenda and it provides Member States with a well-defined action plan to protect development gains from the disaster risks. It works together with the other 2030 Agenda agreements as well, including The Paris Agreement and the Addis Ababa Action Agenda on Financing for Development, Climate Change, the New Urban Agenda, and ultimately the Sustainable Development Goals (SDGs).

The Sendai Framework is also supported by the UN General Assembly following the 2015 Third UN WCDRR, while striving to achieve the aims: livelihoods and health, a considerable reduction in loss of lives, and in the biophysical, cultural, social, environmental and economic assets of persons, communities, businesses and countries as a whole in the next 15 years of period. It also states, a country's responsibility to mitigate disaster risk shall be shared with its stakeholders including government and the private sector and other stakeholders [35]. This research study is basically focused on structural, legal and environmental measures for DRR which is aligned with the goal of Sendai Framework as well. Seven global targets have been agreed on, to assist the assessment of global progress of achieving the goal of the Framework. These will be measured through global level indicators. The seven global targets are listed as follows [35];

1. Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020–2030 compared to the period 2005– 2015
2. Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020–2030 compared to the period 2005–2015
3. Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030
4. Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030
5. Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020
6. Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030
7. Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030

This research study is basically focused on target numbers 3 and 4, which is to reduce the damage caused to buildings and infrastructure of the built environment which will indirectly address the rest of the targets as well. Implementation of the framework will be guided by a set of 12 guiding principles, while considering the local circumstances, and complying with local laws and international regulations. Out of those 12 guiding principles principle 3, 8 and 9 are aligned with the research study as states below [35].

- Guiding Principle 3: Managing the risk of disasters is aimed at protecting persons and their property, health, livelihoods and productive assets, as well as cultural and environmental assets, while promoting and protecting all human rights, including the right to development
- Guiding Principle 7: The development, strengthening and implementation of relevant policies, plans, practices and mechanisms need to aim at coherence, as appropriate, across sustainable development and growth, food security, health and safety, climate change and variability, environmental management and disaster risk reduction agendas. Disaster risk reduction is essential to achieve sustainable development
- Guiding Principle 8: While the drivers of disaster risk may be local, national, regional or global in scope, disaster risks have local and specific characteristics that must be understood for the determination of measures to reduce disaster risk

With the implementation of the HFA and its expected outcomes, there is a need for a focused action within and across different sectors at international, national and regional levels. Sendai Framework has introduced four priority areas as follows [35],

- Priority 1: Understanding disaster risk
- Priority 2: Strengthening disaster risk governance to manage disaster risk
- Priority 3: Investing in disaster risk reduction for resilience
- Priority 4: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction

Out of these 4 priorities, priority 3 and its guidelines were focused, studied and incorporated in this research study in developing disaster resilient green rating tools for built environment. When it comes to my research study, the guidelines under the priorities are divided in to two aspects as, national and local levels and global and regional levels. Only the guidelines under the national and local levels were taken into consideration and incorporated into the rating tools which are as follows [35],

1. To allocate the necessary resources, including finance and logistics, as appropriate, at all levels of administration for the development and the implementation of disaster risk reduction strategies, policies, plans, laws and regulations in all relevant sectors
2. To promote mechanisms for disaster risk transfer and insurance, risk-sharing and retention and financial protection, as appropriate, for both public and private investment in order to reduce the financial impact of disasters on Governments and societies, in urban and rural areas
3. To strengthen, as appropriate, disaster-resilient public and private investments, particularly through structural, non-structural and functional disaster risk prevention and reduction measures in critical facilities, in particular schools and hospitals and physical infrastructures; building better from the start to withstand hazards through proper design and construction, including the use of the principles of universal design and the standardization of building materials; retrofitting and rebuilding; nurturing a culture of maintenance; and taking into account economic, social, structural, technological and environmental impact assessments
4. To protect or support the protection of cultural and collecting institutions and other sites of historical, cultural heritage and religious interest
5. To promote the disaster risk resilience of workplaces through structural and non-structural measures
6. To promote the mainstreaming of disaster risk assessments into land-use policy development and implementation, including urban planning, land degradation assessments and informal and non-permanent housing, and the use of guidelines and follow-up tools informed by anticipated demographic and environmental changes
7. To promote the mainstreaming of disaster risk assessment, mapping and management into rural development planning and management of, inter alia, mountains, rivers, coastal flood plain areas, drylands, wetlands and all other areas prone to droughts and flooding, including through the identification of areas that are safe for human settlement, and at the same time preserving ecosystem functions that help to reduce risks
8. To encourage the revision of existing or the development of new building codes and standards and rehabilitation and reconstruction practices at the national or local levels, as appropriate, with the aim of making them more applicable within the local context, particularly in informal and marginal human settlements, and reinforce the capacity to implement, survey and enforce such codes through an appropriate approach, with a view to fostering disaster-resistant structures
9. To enhance the resilience of national health systems, including by integrating disaster risk management into primary, secondary and tertiary health care, especially at the local level; developing the capacity of health workers in

understanding disaster risk and applying and implementing disaster risk reduction approaches in health work; promoting and enhancing the training capacities in the field of disaster medicine; and supporting and training community health groups in disaster risk reduction approaches in health programs, in collaboration with other sectors, as well as in the implementation of the International Health Regulations (2005) of the World Health Organization

10. To strengthen the design and implementation of inclusive policies and social safety-net mechanisms, including through community involvement, integrated with livelihood enhancement programs, and access to basic health-care services, including maternal, newborn and child health, sexual and reproductive health, food security and nutrition, housing and education, towards the eradication of poverty, to find durable solutions in the post-disaster phase and to empower and assist people disproportionately affected by disasters; People with life-threatening and chronic disease, due to their particular needs, should be included in the design of policies and plans to manage their risks before, during and after disasters, including having access to life-saving services
11. To encourage the adoption of policies and programs addressing disaster-induced human mobility to strengthen the resilience of affected people and that of host communities, in accordance with national laws and circumstances
12. To promote, as appropriate, the integration of disaster risk reduction considerations and measures in financial and fiscal instruments
13. To strengthen the sustainable use and management of ecosystems and implement integrated environmental and natural resource management approaches that incorporate disaster risk reduction
14. To increase business resilience and protection of livelihoods and productive assets throughout the supply chains, ensure continuity of services and integrate disaster risk management into business models and practices
15. To strengthen the protection of livelihoods and productive assets, including livestock, working animals, tools and seeds
16. To promote and integrate disaster risk management approaches throughout the tourism industry, given the often-heavy reliance on tourism as a key economic driver

The Sustainable Development Goals (SDGs) is a collection of 17 global goals introduced by United Nations [28]. These SDGs are also called as the Global Goals, which were adopted by all United Nations Member States since 2015 as a universal call to action to protect the planet, end poverty, and ensure that all people enjoy peace and prosperity by 2030. Targets under SDG 11 (cities) and under SDG 9 (building resilient infrastructure) have a strong interrelationship between DRR and sustainable development. Resilient Construction, sustainable and inclusive industrialization, innovative, resilient, safe and sustainable human settlements and cities are the main goals of the above 2 SDGs [36]. Building and re-building better through proper planning, designing, construction, and retrofitting to withstand natural and man-made disasters contribute in achieving the SDGs related to innovation, construction industry and infrastructure which is directly aligned with this research study.

The Green Building Codes set out the basic standards for initiating a sustainable built environment. So, in achieving the ultimate status where environment flourishes, the economy prospers, and society grows, mainstreaming a disaster risk reduction perspective becomes vital in transforming green buildings into their truly sustainable versions which can withstand against the natural hazards.

2.3 Green Building Councils and Green Rating Systems

The natural environment together with the economy and the health and productivity of the building residents are greatly affected by the built environment. Every year more than a million buildings are designed and constructed and new building materials and construction techniques are introduced and used leaving the old methods behind which had been practiced for years. It has been estimated that the lifespan contribution of the built environment to global CO_2 emissions is around 40%; the greatest individual contributor to global warming [37]. In the present world, concrete is identified as the most consumed commodity next to water. Cement is one of the vital ingredients used in concrete which accounts for around 5% of global CO_2 emissions due to cement manufacturing process. The building sector itself which is mealy a subset of the construction industry acquires more than one-third of total annual energy usage globally (UNEP,2007) [37]. Green Building notion has been introduced to minimize this issue by ensuring sustainable performance throughout the whole life of the buildings and thereby confront the adverse impacts of buildings on natural hazards including global warming and climate change through efficient designs, construction procedures and maintenance of the built environment.

The World Green Building Council (World) has initiated to build sustainable buildings for everyone, everywhere while transforming the buildings and construction sector across three strategic areas of health and wellbeing, climate action, and resources and circularity [38]. WorldGBC is a global leader comprised with nearly 80 Green Building Councils around the world while being the central hub of National Green Building Councils throughout the globe. It also has taken actions to support local and international leadership and empower the community to strive towards the sustainability while minimizing the adverse impacts and influences created on the environment due to building construction [37][38]. WorldGBC has divided its member councils into 5 regions depending on their geographical locations and into 3 membership levels as perspective, emerging and established green building councils according to their capacities and performances as shown in Figure 7. Various countries have a wide spectrum of characteristics of their own such as diverse climatic and weather conditions, wide-ranging environmental, economic and social priorities, traditions or different types of buildings, all of which direct their approach to green building concepts. Therefore, WorldGBC supports its member Green Building Councils and their member organizations in individual nations and across countries, to plan for best fitted green buildings to match their own markets.

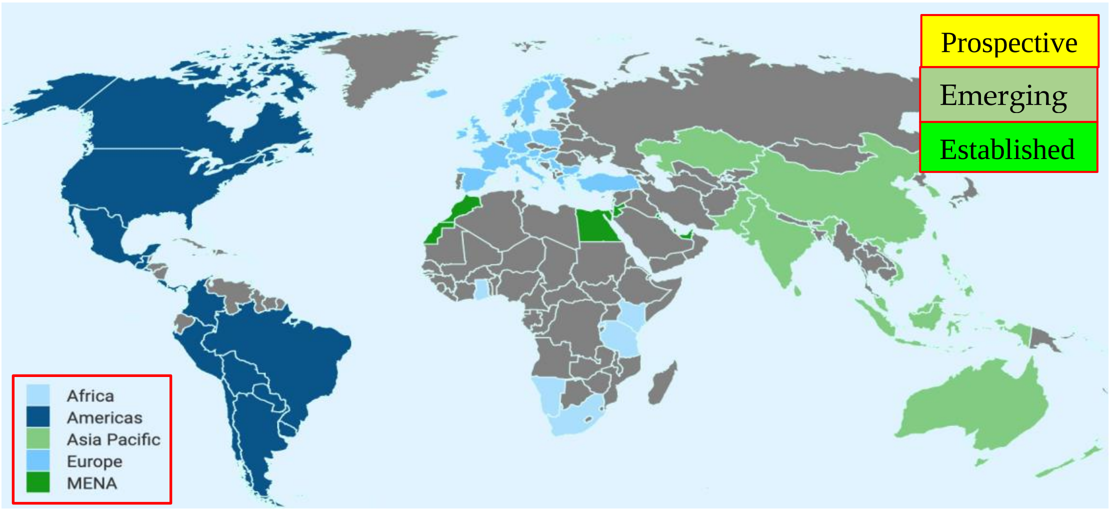

Figure 7: Classification of Green Building Councils by WorldGBC [38]

A 'green' building is a building that, minimizes negative impacts, and make positive impacts, on the environment throughout its life cycle in planning, designing, constructing or operating. Green buildings address the resource scarcity through preserving natural resources [38]. Any building (residential, educational, commercial, medical or any other type) can be made a green building, with the integration of following features [38];

- Effective usage of resources (energy, water etc.)
- Usage of renewable energy (solar energy etc.)
- Reduction re-use and recycling measures
- Indoor air quality
- Usage of non-toxic and sustainable materials
- Environmental consideration in design, construction and operation
- Considering the quality of life of people in design, construction and operation
- Adaptation and flexibility to changing environments

Advantages of green buildings can be categorized under three main segments as environmental, economic and social. One of the highest valued benefits that green buildings provide is to the climate, weather conditions and the natural environment. Green buildings not only minimize the negative impacts for the environment, but also, they reduce the consumption of water, energy and natural resources while creating a positive impact on built environment with the generation of own energy an enhancement of biodiversity to meet the expected demands [38]. The building sector has the highest ability to significantly minimize the emissions of greenhouse gases compared to other emitting sectors in the construction industry [UNEP, 2009] [38] which has been proven through global statics such as [38],

- The Green Star certification of Australia have been shown to produce 62% of lesser emission of greenhouse gases than an average Australian building, and 51% reduced potable water consumption compared with minimum industry requirements.
- Indian Green Building Council (IGBC) certified green buildings show 40 to 50% in energy savings and 20 - 30% in water savings compared with the traditional buildings in India.
- Green buildings with the Green Star certification in South Africa have been shown to reduce between 30 - 40% of energy usage and carbon emissions annually, and between 20 - 30% potable water usage annually, when compared to the general industry norms.
- Green buildings certified with the LEED certification of US Green Building Council and other countries have consumed 25% lesser energy and 11% lesser water, than other normal buildings.

Therefore, green buildings offer numerous financial benefits together with social and environmental gains, which beneficiate a range of different stakeholders. Cost savings on utility bills (mainly energy and water), reduced construction costs and increased property values for buildings, higher occupancy rates for building owners, and new job opportunities are some of them. After publishing of WorldGBC's groundbreaking 2013 report, necessary steps were taken to bring out the connection between benefits and the green buildings. Internationally, world's energy efficiency parameters have been estimated to be around €280 to €410 billion in savings on energy expenses and that is as almost double the annual electricity usage of the United States [European Commission, 2015] [38].

Green building benefits are nor restricted to economics and the environment, but also to bring positive social impacts as well. Most of these benefits are related to health and wellbeing of public who work or live in green buildings such as [38],

- Employees who work in properly ventilated offices report a 101% increase in cognitive scores in brain function [Harvard T.H. Chan School of Public Health / Syracuse University Center of Excellence / SUNY Upstate Medical School, 2015].
- Workers in offices with better openings to the nature such as windows, open spaces with a better ventilation, shown to be slept an average of extra 46

minutes per night than a person who stayed in a non-green building in day time[American Academy of Sleep Medicine, 2013].

- Research has shown that the increase indoor air quality with low amounts of CO_2 and pollutants, and increased rates of ventilation can lead to performance enhancements of employees of up to 8% [Park and Yoon, 2011]

Green Building Councils develop and lead many of world's green rating tools. Approximately 1.04 billion square meters of green building spaces (an area 10 times the size of Paris) had been certified around the globe through member Green Building Councils by 2016 [38]. WorldGBC has recognized the influence that green rating tools have had in incorporating the sustainable characteristics to buildings while promptly supporting their usage and application. Every rating tool has their own uniqueness which makes the rating tools differ from one to another, and that each of the member Green Building Council in a specific country is given the freedom to develop their rating tools, best fit to each country's social, environmental and economic conditions and their market condition and types. However, with the rapid and widespread use of rating tools around the globe, WorldGBC strictly believes that each and every green building rating tool must meet quality standards and be robust and transparent to maintain their standards.

Green building rating systems or green building codes can be defined as a set of guidelines and criteria which a building or a structure is used to assess and recognize when certain green requirements or standards are met [38]. Rating tools differ based on their application stages as they are applied for all most all the life cycle stages of a green building. Rating tools can again categorize based on types of buildings that are applied with special tools such as residential buildings, commercial buildings or even entire neighborhoods. Generally, they are designed through a systematic process by organizations such as the American National Standards Institute (ANSI), the American Society for Testing and Materials (ASTM), Refrigerating and Air-Conditioning Engineers (ASHRAE), the American Society of Heating, or when considering Sri Lanka, the GBCSL. These guidelines and criteria are either be (1) the prescriptive type or (2) the performance-based type, when it comes to their implementation mechanism. Performance-based type is more sparing and tolerant as it does not prescribe specific materials and equipment but instead, it sets the minimum allowable performance targets for resource usage whereas the prescriptive type is stricter and more rigorous as it prescribes specific materials and equipment to be complied with. Again, most of the rating systems in the world, though inherently promote resilience, specifically target the reduction of resource usage and energy consumption.

For the last three decades, both developed and developing countries have worked on establishing their own legislations and green building rating systems to foster green and sustainable developments [39]. We have the world's longest established rating system, BREEAM in United Kingdom, being established in 1990, LEED in United States of America, GREEN STAR in Australia, GRIHA in India, SAGRS in Saudi Arabia, LOTUS in Vietnam, CASBEE in Japan, GREENSHIP in Indonesia and BERDE in Philippines, to name a few. The goals and objectives of these rating systems primarily revolve around promoting sustainability. A real long-term solution to the problem, however, is to integrate resilience into developments for them to help the people to withstand, recover, and transform, each time a hazard hits (Champagne & Aktas, 2016). As discussed under Research Scope, the literature review of the research is narrow down to few rating systems, which are, LEED and ReLi of Green Building Council of United States, CASEE of Japanese Green Building Council, GREENSHIP of Green Building Council of Indonesia and BERDE of Green Building Council of Philippines for the research and next few subcategories will be allocated for the literature review of those rating systems.

2.3.1 Leadership in Energy and Environmental Design (LEED) by United States Green Building Council (USGBC)

LEED (Leadership in Energy and Environmental Design) that has been brought out by the United States of America's Green Building Council provides a rating system for all the phases of a project life cycle (design, construction, operation and maintenance) of green buildings with high-performance is the most widely used rating system in the world. During last 18 years, the global green building market has been pushed forward progressively through various versions of LEED has more than 93000 assessed projects with more than 19 billion square feet of space worldwide across 160 countries and territories. According to USGBC estimations, nearly 5 million people are experiencing a LEED building daily. LEED certification has been earned by many of the most highlighted buildings in the world. LEED provides a framework for healthy, efficient, and cost-reducing green buildings that drives building owners and operators for being environmentally responsible and efficient usage of resources. USGBC operates with the vision of regenerating buildings and communities and sustaining the health and vitality of all life within a generation.

LEED certification ensures not only the productivity of any institution, but also minimized stress on the environment through efficient utilization of resources. buildings but also cost reductions from increased values of the property/building, higher rates of leasing and decreased maintenance and utility costs. A recent study based on the market of San Diego shows that the total rate of vacancy for green buildings is lower than that for non-green buildings by 4% and that LEED-certified buildings can attract higher rents [40]. Moreover, LEED projects currently divert over

80 million tons of waste from landfills. When comparing with an average commercial building, On the other hand, it is believed by 61% of corporate leaders that market is properly differentiated and financial performance is improved through sustainability and a LEED-certified building can increase recruitment as well as retention rates. Also there will be increased benefits from productivity for employers where 2.5 million employees get the opportunity to experience better indoor environmental quality in LEED buildings [40].

Since 1998 LEED has developed into more accurate versions with emerging green building technologies. LEED v4 was introduced in November, 2013 [40]. LEED is applicable for all building types and all building phases (including new construction, interior fit outs, operations and maintenance and core and shell) and it consists of ten rating systems for the life cycle of all types of buildings and neighborhoods. There are five categories in connection with the specialties available under the professional program LEED. That currently consists of the following [40];

- Green Building Design & Construction
    1. LEED for New Construction
    2. LEED for Core & Shell
    3. LEED for Schools
    4. LEED for Retail: New Construction and Major Renovations
    5. LEED for Healthcare
- Green Interior Design & Construction
    6. LEED for Commercial Interiors
    7. LEED for Retail: Commercial Interiors
- Green Building Operations & Maintenance
    8. LEED for Existing Buildings: Operations & Maintenance
- Green Neighborhood Development
    9. LEED for Neighborhood Development
- Green Home Design and Construction
    10. LEED for Homes

The LEED performance credit system allocates points for the potential environmental and human benefits that have been weighed. Each Category of the rating system has pre-requisites which are mandatory measures to be achieved and carry no points and credits which are optional measures under each category which carry points. Based on the cumulative points scored through completing pre-requests and credits under the all categories of the rating tool, buildings will be qualified in four levels of certifications,

- 40-49 points - Certified

- 50-59 points - Silver
- 60-79 points - Gold
- 80 points and above - Platinum

Out of all the rating tool types and categories, Green Building Design & Construction type was selected for the in-depth study under the literature review. Under the Design & Construction of Green Building type, LEED for New Construction and Design rating tool was specifically selected to study the how and to what extent the DRR and disaster resilient mechanisms have been incorporated or integrated. LEED v 4.1 for New Construction and Design rating tool comprises of 9 categories with their respective points (total of 110 points) as listed below [42];

1. Integrative Process (IP): 1 Point
2. Location and Transportation (LT): 16 Points
3. Sustainable Sites (SS): 10 Points
4. Water Efficiency (WE): 11 Points
5. Energy and Atmosphere (EA): 33 Points
6. Materials and Resources (MR): 13 Points
7. Indoor Environment Quality (IQ): 16 Points
8. Innovation (IN): 6 Points
9. Regional Priority (RP): 4 Points

Now let's see how much and to what extent the DRR and disaster resilient mechanisms have been incorporated or integrated into the LEED v 4.1 for New Construction and Design rating tool using Table 2.

However, the baseline used by Champagne and Aktas for the assessment of the resilience of LEED seems to lack solid underpinnings with any of the United Nations (UN) Actions Plans for Resilience – i.e. Hyogo and Sendai Frameworks [44]. The baselines used in the assessment, which were all lifted from different are as follows [44];

- Drainage design based on future climate models
- Environmentally-friendly communities
- HVAC systems designed for future, warmer, capacities
- Local, inexpensive materials and resources
- Low energy inputs
- Reduction of greenhouse gas emissions
- Renewable energy for less reliability on grid power
- Strong building envelope
- Water capture and storage
- Water usage reduction to counter increasing temperatures

- Water, fire, and pest resistant materials
- Weather resistant pavement design
- Wildfire air quality control

Table 2: DRR and Disaster Resilient Mechanisms Incorporated in to the LEED v 4.1 for New Construction and Design Rating Tool [46]

Main Category	**Sub-Category (Pre-request/ Credit)**	**DRR Measure**
Location and Transportation (LT)	Credit: Sensitive Land Protection	• A flood hazard area shown on a legally adopted flood hazard map or otherwise legally designated by the local jurisdiction or the state. For projects in places without legally adopted flood hazard maps or legal designations, locate on a site that is entirely outside any floodplain subject to a 1% or greater chance of flooding in any given year. • Wetlands. Areas on or within 50 feet (15 meters) of a wetland, except for minor improvements
Sustainable Sites (SS)	Pre-request: Construction Activity Pollution Prevention	To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust. Create and implement an erosion and sedimentation control plan for all construction activities associated with the project. The plan must conform to the erosion and sedimentation requirements of the 2017 U.S. Environmental Protection Agency (EPA) Construction General Permit (CGP) or local equivalent, whichever is more stringent. The plan must describe the measures implemented.
	Credit: Site Assessment	• Topography: Contour mapping, Unique topographic features, Slope stability risks • Hydrology: Special Flood Hazard Areas (SPFHA) as determined by FEMA's, Flood Insurance Rate Map (FIRM) (or local equivalent for projects outside the

		U.S.), Delineated natural water bodies wetlands, lakes, streams, and shorelines (refer to U.S. EPA's Clean Water Act or local equivalent for projects outside the U.S.), Rainwater collection and reuse opportunities, Impervious and pervious surfaces within the site boundary • Soils: Previous development

2.3.2 RELi Rating System by U.S. Green Building Council

The lack of resilience concepts integrated with LEED drew the attention of the USGBC and a separate system for rating developments on resilience was brought up. RELi was launched in 2017 to recognize existing leadership programs such as LEED to adapt and thrive in changing environments. Differentiating from other rating systems for disaster resilience available, RELi merges specific design criteria for haards, like preparedness for hazards and also the generic measures. RELi's system of requirements and credits does not only act as a benchmarking system but with the certification obtained by GBCI, it improves the accountability of a project at all levels.Though it differentiates from LEED, some of the credits and criteria of these two tools still overlap. RELI was developed first by the Institute for Market Transformation to Sustainability (MTS) for the use of pilot projects in 2014, following the American National Standards Institute-approved National Consensus Process [45].

Since societies and structures are undergoing weather extremes, economic disruption and resource depletion resilient designs are vital. The LEED Resilient Design pilot credits and RELi's Hazard mitigation and Adaptation credits have been synthesized in the new RELi 2.0 Rating System , the latest version which was introduced in late 2018 as a wholistic and integral rating system with noval design criteria .With RELi's points for innovative segments included, RELi 2.0 can be considered as the most holistic rating system currently available for socially and environmentally feasible design and construction [45].

Criteria of RELi 2.0 include severe hazard preparation, adaptation and prevention strategies at both the building and neighborhood scales. RELi 2.0 was only available for projects that were in the process of seeking LEED certification as of 2018. Through this, eligible projects are given the opportunity to work with certification teams and improve their resilient designs. RELi 2.0 does not provide design guidelines for indefinite building and community operation following a catastrophe. RELi 2.0 certification works on a credit system and the certification level a project receives is determined by the number of points that a project earns. The 15 requirements under main 8 categories of the rating system are compulsory and do not have point values. But other credits that are optional carry point values where projects have the choice of targeting for the certification level that fits their needs. Point values are as follows [46]:

- RELi Certified: 300 – 349 Points
- RELi Silver: 350 – 449 Points
- RELi Gold: 450 – 599 Points
- RELi Platinum: 600 – 800 Points

RELi introduces a comprehensive series of new criteria focused on environmental, social, and economic considerations for resilience. Credit-generating categories of many other rating tools incidentally improve resilience as well while improving sustainability. But, RELi's credit-generating categories focus on creating resilient buildings and communities and together with CASBEE, to set baselines from, it makes the ideal tool for improving resilience. The main 8 categories mentioned above are [46];

- Panoramic Approach (PA)
- Hazard Preparedness, short-term hazard preparedness, Mitigation + Adaptation (HP)
- Hazard Mitigation + Adaptation (HA)
- Community Cohesion, Social+ Financial Vitality (CV)
- Efficiency, Health + Diversity (PH)
- Resources, Water + On-site Food Production (EW)
- Materials + Artifacts (MA)
- Applied Creativity (AC)

RELi 2.0 mainly focuses on structures where buildings and homes are the main considerations and communities where neighborhoods (people) and infrastructures are the main considerations. RELi 2.0 is a resilient tool which is not only focused on DRR and disaster resilience, but also it focuses on many types of resilience such as water, energy, food, resources, health, food and productivity, etc. Now let's see how much and to what extent the DRR and disaster resilient mechanisms have been incorporated or integrated into the RELi 2.0 resilient tool using the Table 3. [46].

Table 3: DRR and Disaster Resilient Mechanisms Incorporated in to the RELi 2.0 Resilient Tool [46]

	Sub-Category (Pre-request/ Credit)	**DRR Measure**
	Req. 1.0: Study: Short-Term Hazard Preparedness + Mitigation	Study and report on the potential physical and procedural actions that can be taken by the project to prepare for + mitigate short-term hazards to the building and community occupants, physical property + physical infrastructure not limited to Extreme Weather + Rain, drought, landslide, fire/wildfire, flooding, seismic events, storm surge, snow slide, volcanic activity and wildfire.
	Credit 6.0: Study + Design for Long-Term Adaptability, Diversity + Redundancy	• Restore and rehabilitate the effects of long-term change, including desertification, beach erosion, and loss of wetlands. Shoreline restoration activities also minimize the effects of climate change on inland populations, including flooding and extreme weather events. • Implement plans and designs to prepare for long-term climate and resource change including the effects of increased intensity and frequency of extreme weather events, water scarcity, sea level rise, extended droughts and heat waves, and increased ambient temperature.
	Req. 1: Fundamental Emergency Planning for Common Hazardous Events	Provide fundamental safety for occupants during periods of disaster and/or emergency by developing an Emergency Preparedness Plan. Prepare and implement a Fundamental Common Hazards Emergency Preparedness Plan for the facility using the American Red Cross SMB (Small Business) Prepared Playbook: Emergency Preparedness Tips for Small Businesses. Use the Hazard

		Vulnerability Assessment Worksheet to assist the planning effort mainly for wildfire, floods and flashfloods, hurricanes, tornadoes, severe winter storms and earthquakes.
	Req. 2: Fundamental Access To: First Aid, Emergency Supplies, Water, Food, Communications	• Provide fundamental safety for facility occupants during common emergencies for at least a 96-hour period (four days). Provide the items such as First Aid Kit and First Aid Training and CPR Training, for Mission-Critical Facilities, including residential facilities with overnight occupancy at the residential and commercial scale. • Provide at least one telephone land-line along with a cell phone with text message capabilities and an emergency alert radio + walkie-talkies (or similar) at minimum.
	Credit 1: Enhanced Emergency Planning for Common Hazards + Extreme Events	• Provide fundamental safety for occupants during periods of disaster and/or emergency. Enhanced Emergency Planning for Common Hazards + Extreme Events using, communications, life safety, property protection and community outreach. • Expand the FEMA Guide 141 Planning Considerations by including the following aspects such as, Map the Hazardous Materials present in your Area, Identify Extremely Hazardous Material Risks in your Area, Locate EPA, State and Tribal Facilities of Interest in Your Area and Locate facilities with EPA non-compliance records
	Credit 2: Enhanced Access: Emergency Care + Supplies,	Provide safety for occupants during periods of disaster and/or emergency such as, Enhanced First Aid Kit, High-

	Water, Food, Communications	Demand/Short Supply items, Unique-need items, Enhanced First Aid Training, Enhanced Access to Emergency Care, Enhanced Emergency Sanitation, Enhanced Communication Capacity + Equipment, Provide Portable Emergency Lighting, Provide Work and Security Lighting and Provide Emergency Back-up Power for Communications and Portable Emergency Lighting.
	Credit 4: Community Education: Ever increasing Weather, Safety + Resiliency Risks	Inform and educate the public and authorities about increasing weather, safety and resiliency risks including critical and non-renewable resource availability and long-term economic indicators
	Req 1: Sites of Avoidance + Repair: 500-Year Floodplain, Storm Surge + Sea Rise	• Floodplain: Avoid areas within 500-year floodplain. Statistically, the traditional 100-year floodplain has been found vulnerable to extreme events and sea level rise. Even in areas with prolonged drought, storm events, when they occur, are more intense, making the 500- year floodplain level appropriate for underwriting • Sites Not Permitted: Building on green field sites below the 500-year floodplain is not permitted. • Sea Level Rise: Avoid coastal zones inundated by 2'-6" of sea level rise, or provide an engineering solution
	Req 2: Fundamental Emergency Operations: Back-up Power + Operations	• Design for protection from power outages from the grid, including those caused by floods, under capacity, civil disturbances, hurricanes, high winds, and intense storms of all kinds including ice, and heatwaves. • Provide permanent back-up power, switching gear and/or power hook-ups, and infrastructure for temporary generators to provide power for critical

		utilities such as HVAC and boilers. Locate equipment and infrastructure above the 500-year floodplain. • If the equipment is not sufficiently elevated as described above, then dry flood protection such as flood gates, walls, doors and/or inflatable barriers must be provided to prevent water intrusion into these vulnerable areas.
	Credit 2: Advanced Emergency Operations: Thermal Safety, Lighting, Critical Services, Water	Back-up Power + Operations: Back-up power is provided by cleaner burning fuel sources and combinations: Biomethane, Natural Gas, Propane, Biodiesel and/or Diesel bi-fuel generators allowing for operation on 100% Biomethane, Natural Gas, Propane after start-up and percentage of island able power and fuel needs come from renewable sources
	Credit 4: Transit + Transportation System Protection + Continuous Operations	Provide and Maintain Flood Protection + Energy Resiliency in transportation systems for short-term and long-term resiliency. Transit Protection from Flooding and Extreme Events such as, protect below ground system vents and entrances from flooding*)*, Plan systems for 500-year floods, Plan systems for extreme rain events as calculated above and Provide distributed generation power sources.
	Credit 5: Environmental Protection + Remediation for Parks + Preserves	Provide protection for public assets and the public commons in times of emergency and disasters through methods such as, develop detailed action plans and stow needed supplies on-site to protect Parks + preserves from flooding or protect and Restore and develop infrastructure, including natural based systems to protect Parks + Preserves from flooding
	Credit 1: Incorporate Important Community	Design the project in a way that maintains the local character of the community and does not have negative impacts on

	Views + Aspects of Local Landscape	community views, helping to maintain or develop local connectivity and appreciation for place and nature, and local social connectivity and cohesion. Get community views and feedbacks in designing resilient measures including evacuation process planning, evacuation and rescue shelters, evacuation routes, warning systems and rescue processes.
	Credit 4: Expand Citizen Participation: Public Amenities, Councils, Organizations, Communications	• Actively participate in a local, regional or national disaster recovery program(s) including but not limited to one organized under the National Recovery Framework • Organize and Develop a Community Communication Tools such as radio network, telephone network and newsletters for community awareness and emergency response.
	Req 2: Minimum Protection for Prime Habitat + Floodplain Functions	Preserve Floodplain Functions/Improved Performance - Avoid or Mitigate Impacts, Avoid or limit new development within the design frequency floodplain for waterways of all sizes, unless water dependent infrastructure must cross or be adjacent to a waterway. Design water dependent infrastructure to minimize floodplain impacts or waterway crossings. Maintain predevelopment floodplain storage that does not increase flood elevations.
	Credit 5: Ecological HPD: Protect Wetlands + Avoid Slopes + Adverse Geology	• Protect Wetlands and Surface Water: Establish a vegetation and soil protection zone (VSPZ) for an area within 100 feet of any wetland areas, shoreline, or bodies of water or within setback distances from wetlands prescribed in state or local laws and/or regulations, whichever is more stringent. • Avoid Adverse Geology: Prior to project siting, the owner and the

		project team identify and delineate any faults, low-lying coastline and karst areas in and around the project site. Identification and delineation include location, distribution, characteristics and groundwater hydrogeology, including flow and quality. Develop plans and designs to reduce the risk of damage due to ground motion, tsunami flooding and collapse of karst areas and associated aquifer damage, or from the hazards of these areas • Avoid Unsuitable Development on Steep Slopes: Identify relative landslide, subsidence and liquefaction risk, and critical slopes risk that may indicate unstable soil. Refer to state and local data1 to determine whether the project is located in a high-risk landslide area and whether there is land on or uphill of the building site with a slope exceeding 15% (6.75°)
	Req. 1: Minimum Water Efficiency + Resilient Water + Landscapes	Maintain a dynamic balance with surface water, aquifers, rain events and water use; maintain a manageable condition with the site and regional hydrology during extreme rain events, periods of flooding and droughts, etc. through Rainwater Management
	Credit 1: Plan for Rainwater Harvesting, Resilient Landscapes + Food Production	Rainwater Management + Water Recycling/Reuse: Space and Planning: Plan the structure and site to provide for roof and/or ground level collection of rainwater and/or for project uses such as landscape irrigation, toilet flushing, process water of all kinds, and with proper filtration, potable use. Plan a minimum of 50% of the roof area to capture water for reuse.

	Credit 3: Water Efficiency + Resilient Water + Landscapes	Rainwater Harvesting, Recycled Water, On-Site And/or Neighborhood Water Storage: Provide on-site rainwater or recycled water storage to cover operations, including toilet flushing and mechanical equipment (if needed) for emergency stand-alone operations for a period of at least 96 hours and Reduce potable water for building sewage conveyance by 50% through the use of Rainwater Harvesting and/or the use of recycled water.

2.3.3 Comprehensive Assessment System for Built Environment Efficiency (CASBEE) by Japanese Green Building Council (JGBC)

Comprehensive Assessment System for Built Environment Efficiency (CASBEE) is a green rating system used for assessing and rating the environmental performance of buildings and the built environment. CASBEE was developed and established in 2001 as a collaborative effort of industry, acadmia and national and local governments, which also established the Japan Sustainable Building Consortium (JSBC) under the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). CASBEE was developed aiming to enhance both the people's quality of life and to minimize the resource usage in project life cycle and environmental loads related to the built environment, from a unit residential building to a city. With the rapid urbanization and increased pollution, various CASBEE rating systems were developed based on different types of built environments across Japan, ruled by national and local governments. Achour argued that CASBEE represents a successful attempt to integrate resilience and sustainability [47] which was also supported by Madu and Kuei in their handbook of Disaster Risk Reduction and Management where they declared that while most of the green rating tools do not recognize the connection between sustainability and resilience as they give more focus on addressing environmental and social impacts, CASBEE offers a much wider perspective as it addresses resilience more comprehensively while addressing sustainability [48].

CASBEE by JGBC is defined as a green rating tool that is designed to both elevate the quality of life of people and to minimize the resource usage and environmental loading in the built environment [49]. It assesses the quality of service and ability to withstand during hazardous events like earthquakes, storms, and also anthropogenic hazards, through various checks like compliance with codes and manuals (earthquake resistance code etc.), service life of components, reliability, etc. It further assures and checks on the effects created by construction on external infrastructure like the relationship with utilities service providers; making CASBEE, together with RELi, the most ideal systems to set as a baseline [49]. When it comes to the certification types of CASBEE Family rating systems based on their points systems, it's bit different from the rest of the pointing and certification systems when compared with other green rating tools and systems [50].

- BEE ≥ 3.0: S (Excellent)
- 3.0 > BEE ≥ 1.5: A (Very Good)
- 1.5 > BEE ≥ 1.0: B+ (Good)
- 1.0 > BEE ≥ 0.5: B- (Fairly Poor)
- BEE < 0.5: C (Poor)

Above BEE value is calculated using the following equation, Equation 4 as follows [50],

$$Built\ Environment\ Efficiency\ (BEE) = \frac{Q\ (Built\ Environmnet\ Qulaity)}{L\ (Built\ Environmnent\ Load)}$$

Equation 04: BEE Value Calculation Equation

CASBEE tools are designed based on 4 main categories which are, housing scale, building scale, urban scale and city scale. Therefore, CASBEE is consist of rating tools designed with various scales: construction, urban and city management. Altogether these tools are named as the CASBEE Family [49]. Also, on the other hand, CASBEE is composed of four assessment tools depending on the development stage and its life cycle, that are namely, CASBEE for Pre-design, CASBEE for New Construction, CASBEE for Existing Buildings and CASBEE for Renovation. CASBEE is a group name for a number of tools of the CASBEE family, each tool prepared related to the type of building or the objective of assessment. Following are the main tools comes under CASBEE family [49];

- CASBEE for Buildings (New Construction)
- CASBEE for Buildings (Existing Buildings)
- CASBEE for Buildings (Renovation)
- CASBEE for Market Promotion
- CASBEE for Commercial Interiors
- CASBEE for Temporary Construction
- CASBEE for Heat Island
- CASBEE for Urban Development
- CASBEE for Cities
- CASBEE for Cities - Pilot version for worldwide use
- CASBEE for Detached Houses (New Construction)
- CASBEE for Homes (Detached Houses)

- CASBEE for Dwelling Unit (New Construction) 2014 edition
- CASBEE Health Checklist
- CASBEE for Housing Renovation Checklist
- CASBEE Community Health Checklist

Main focus for the research study and the literature review was based on CASBEE for Buildings - New Construction (NC). CASBEE-NC is mostly utilized by engineers and architects to enhance the BEE value of a building within its design phase which is also used as a design support tool as well as a self-checklist while assessing and evaluating the rebuilding projects at any phase; Preliminary or Execution Design, Completion of Construction, the quality of environment and the building's load reduction performance. As scoring criteria and environmental performance vary with time, the assessment results are valid only for three years after completing the construction [50]. CASBEE-NC consists of 2 main sections and each section consists of 3 categories, which boils down to a total of 6 categories. Those sections, categories and their subcategories are listed below [50],

- Environmental Load Reduction of Building
    1. Energy
        a) Heat Load Control
        b) Natural Energy Utilization
        c) Building Service System
        d) Efficient Operation
    2. Resources & Materials
        a) Water Resources
        b) Renewable Resources
        c) No pollutant Materials
    3. Offsite Environment
        a) Global Warming
        b) Local Environment
        c) Surrounding Environment

- Environmental Quality of Building
    4. Indoor Environment
        a) Sound
        b) Thermal Comfort
        c) Lighting & Illumination
        d) Air Quality
    5. Quality of Services
        a) Service Ability
        b) Durability & Reliability
        c) Flexibility & Adaptability

6. Outdoor Environment
    a) Biotope Conservation
    b) Townscape & Landscape
    c) Local Characteristics

Now let's see how much and for what extend the DRR and disaster resilient mechanisms have been incorporated or integrated into the CASBEE-NC rating tool [50]. Mainly CASBEE-NC rating tool is focused on earthquakes as Japan is a country which is highly vulnerable to earthquakes. Apart from earthquakes, they have not much considered about other hazards in their CASBEE-NC rating tool. Under the Environmental Quality of Building section, Quality of Services category and Durability & Reliability sub-category, the DRR, disaster resilient, structural and non-structural measures regarding Earthquake Resistance, Seismic Isolation & Vibration Damping Systems have been listed. As earthquake hazards are out of the scope of this research study, it's not been further explained here.

Due to the lack of DRR and disaster resilient measures about floods, landslides and heavy winds, which have been considered as the research scope of this study, and due to need of studying about city tools, required in the later part of the research study, CASBEE for Urban Development (CASBEE-UD) was referred in getting the required information which covers the scope of the study. CASBEE-UD governs groups of buildings and cities. It concerns the incorporation of effort of humans and impacts created through building groups that enhance the overall performance of urban environment. CASBEE tools used for housing units and buildings are named as "building-scale CASBEE" to differentiate them from CASBEE-UD. CASBEE-UD is a green rating tool centered around the building-scale CASBEE concept and is an expanded CASBEE tool, developed based on the Q3 (Outdoor Environment on Site) and LR3 (Off-site Environment) of CASBEE-NC [51]. However, CASBEE-UD is applied for a part or a complete building and it is targeted on the circumstances that may occur due to building conglomeration. Assessment of Interior of buildings are excluded in CASBEE-UD Therefore, it is possible to use CASBEE-UD to assess a developed area fully, while building-scale CASBEE can be utilized to assess the environmental performance of single buildings within the specific area [51].

CASBEE-UD rating tool has main three categories as environment, society and economy. Under the society category and Security/Safety subcategory of CASBEE-UD rating tool, it has been considered about the DRR and disaster resilient measures for other hazards. Mainly tool has focused on Disaster Prevention and Disaster Response measures. Following are the main measures, it has considered under the above 2 aspects which have been incorporated in developing the disaster GREENSL® resilient rating system for built environment [51];

- Disaster Prevention
    - ✓ Understanding of Hazard Maps
    - ✓ Preparedness with Communication, Water Supply /treatment & Energy Supply Infrastructures during an emergency.

- Disaster Response
    - ✓ Formation of evacuation routes and sites/shelters
    - ✓ Emergency Operations required for the continuity of Business and lifestyles

2.3.4 GREENSHIP Rating System by Green Building Council of Indonesia

Green Building Council of Indonesia (GBC Indonesia) is an independent body, established in 2009 by design and construction experts who are keen on green building concepts and practices. GBC Indonesia is an Established Member of WorldGBC, of which the head quarter is situated in Toronto, Canada. The main concern of this is to transform and socialize the sustainable and green principles in the sector of building construction in Indonesia. In executing its activities, GBC Indonesia works hand in hand with all stakeholders of both government and private sectors. GBC Indonesia has 4 main programs which are namely, market transformation, training & education, green building certification and stakeholder engagement [52].

For benchmarking the green buildings in Indonesia, GBC Indonesia has developed a rating system titled GREENSHIP. In the development process of GREENSHIP, it has been considered the country conditions, natural character and regulations as well standards that is already applied in Indonesia [52]. Building, construction industry and built environment professionals such as architects, interior designers, mechanical and electrical engineers, as well landscape architects had been developed the GREENSHIP. GBC Indonesia had developed and published 5 type of GREENSHIP rating tools [52]:

a. GREENSHIP New Building
b. GREENSHIP Existing Building
c. GREENSHIP Interior Space
d. GREENSHIP Homes
e. GREENSHIP Neighborhood

Considering the research scope of this research study, GREENSHIP New Building rating tool was selected for further studying and extracting relevant DRR and disaster resilient measures which can be incorporated in developing the disaster resilient green rating system for built environment. Also, GREENSHIP New Building Version 1.0 has been revised as GREENSHIP New Building Version 1.1 which is valid from February 23rd 2012 and it is the tool which has been considered for the literature review under this research study [53]. Same as the other rating systems, GREENSHIP New Building rating tool also has its own certification system according to a points allocation. When it comes to certification and points allocation methods, GREENSHIP New Building rating system as 2 major certification criteria and points allocation systems as shown below [53],

1. Design Recognition (DR) Achievement (with maximum 77 points)
    - Platinum: Minimum percentage is 73% with 56 points
    - Gold: Minimum percentage is 57% with 43 points
    - Silver: Minimum percentage is 46% with 35 points
    - Bronze: Minimum percentage is 35% with 27 points

2. Final Assessment (FA) Achievement (with maximum point 101)
    1. Platinum: Minimum percentage is 73% with 56 points
    2. Gold: Minimum percentage is 57% with 43 points
    3. Silver: Minimum percentage is 46% with 35 points
    4. Bronze: Minimum percentage is 35% with 27 points

Same as other rating systems, all GREENSHIP rating tool categories carry the pre-requisite criteria and mandatory requirements to fulfill. But fulfillment of Credit Criteria is on voluntary basis in all GREENSHIP categories. The sum of credit criteria points will be summed up for 100% and higher the number of points fulfilled; a higher GREENSHIP level will be achieved. The fulfillment of some criteria which are bonus criteria is purely on voluntary basis as these criteria are bit hard to be achieved. Project should be fulfilled with 7 eligibility criteria before announced as a registered project. The eligibilities are [53]:

1. Minimum building area is 2500 m2
2. Data Project Transparency
3. Compliance with Detailed Spatial Plan
4. Having Environmental Management System
5. Compliance with Fire Protection Standard
6. Compliance with Earthquake Resistance Standard
7. Compliance with Accessibility Standard for Disabled People

GREENSHIP New Building rating tool consists of six major categories with pre-request and credit criteria as mentioned above. The categories are [53],

I. Appropriate Site Development (ASD)
II. Energy Efficiency & Conservation (EEC)
III. Water Conservation (WAC)
IV. Materials & Resources Cycle (MRC)
V. Air Quality & Leisure Air (Water Indoor Health & Comfort / IHC)
VI. Building & Environment Management (BEM)

Indonesia is one of the main disasters affected regions in the world. It is prone to many natural disasters such as floods, landslides, tsunami, earth quakes, volcano, and cyclones [54]. According to records, since 2004, Indonesia has experienced disasters every month . This has caused enormous loss of lives, disruption of construction in whole islands, and instabilities and fluctuations in economy [55]. The government of Indonesia is spending around $300 to $500 million annually to deal with post-disaster mechanisms of recovery and built back better. But some of them will be in vain due to climatic changes. Furthermore, in years where main disasters hit, the cost of recovery from post-disaster damages was 0.3% of the national GDP of the country and 45% of provincial GDP [55]. During the past thirty years disaster losses have accounted nearly for $3.5 trillion. Therefore, it is very hard to build up and develop industries since they get affected on a yearly basis by natural hazards such as tsunamis, earthquakes, floods, and landslides. Due to the tsunami which affected the coastline of the Sundra Strait in 2018, it has been understood that Indonesia is still on its way of mitigating the adverse impacts caused by natural disasters that affect Indonesia immensely although they have many laws, acts, guidelines and frameworks developed based on DRR [55]. Now, let's see how much and for what extend the DRR and disaster resilient mechanisms have been incorporated or integrated into the GREENSHIP New Building Version 1.0 rating tool by GBC Indonesia being a highly hazard prone country [53].

- There's an eligibility criterion named "Compliance with Earthquake Resistance Standard" which is to be fulfilled mandatorily in designing and constructing buildings. As the scope of this research study is out of earthquake hazards, further literature survey was not carried on this eligibility criterion.

- Other DRR and disaster resilient mechanisms that have been incorporated or integrated into the GREENSHIP New Building Version 1.0 rating tool are listed using the Table 4 [53].

Table 4: DRR and Disaster Resilient Mechanisms Incorporated in the GREENSHIP New Building Version 1.0 Rating Tool [53]

Main Category	**Sub-Category (Pre-request/ Credit)**	**DRR Measure**
Appropriate Site Development (ASD)	Credit 7: Storm Water Management	To reduce the load of environment drainage system from the quantity of rain water runoff with an integrated rain water management system which will show a reduction of rainwater runoff volume into the city drainage network from building

		site and show an effort to reduce flooding from outside building area
Energy Efficiency & Conservation (EEC)	Credit 4: Climate Change Impact	To provide and increase the knowledge related to the effect of excessive energy consumption towards climate change

2.3.5 Building for Ecologically Responsive Design Excellence (BERDE) by Green Building Council of Philippines

As set of leaders in the business and environmental sector in 2006, realized the need of an organization to promote greener buildings and move towards a sustainable built environment. As a result, the Philippine Green Building Council (PHILGBC) was established in early 2007 as a native and a not for profit company which strives to distribute knowledge and improve greener and sustainable construction practices to industries in order to encourage them for a sustainable Philippines [56]. Since then PHILGBC has been striving for a greener and a sustainable transformation of all phases of construction (design, construction and operation) into practices that are safe, healthy and environmentally, socially and economically responsible. [56]. PHILGBC is an Emerging Member of the WorldGBC which represents the Asia Pacific Network. The council has been developing the Building for Ecologically Responsive Design Excellence (BERDE) Rating System, acknowledged by Department of Energy in 2012. BERDE identifies the mechanism that a building performs better than the country's normal standards [56] [57]. Therefore, BERDE can be defined as a green rating system used to evaluate, monitor, and certify the performance of green building projects exceeding the existing local building and environmental laws and regulations [57]. BERDE Certification is a balanced, unbiased, credible and impartial assessment system which is obtaining through a third-party certification process conforming to a set of international standards. Certification process for projects have to pass through few assessment stages which is based on the project's life cycle. There are 3 main assessment stages. They are [57],

- Stage 1: Design
- Stage 2: Construction
- Stage 3: Operations

Stage 1 is based on Design which is focused on planning and designing of new buildings and renovation or fit-out projects of existing projects [57]. Stage 2 is based on Construction which is focused on verifying the construction, renovation or implementation of approved projects under stage 1. Only the projects which have been able to complete stage 1 are eligible to apply for the certification of stage 2. During stage 2, an on-site assessment will be carried out to validate the project work awarded under stage 1 plans. Stage 3 is focused on operations stage of the projects which is concerns the assessment and verification of the planning and implementation of the policies and procedures of the project [57]. Projects can be registered directly under Stage 3: Operations for certification. Therefore, all kinds of new and existing buildings (commercial, residential, public and private, etc.) are using the same BERDE rating system in obtaining the green certification. The lowest level of certification of BERDE rating system is a 1-Star rating whereas the highest is 5-Star rating. Following are the BERDE Star rating certification depending on the percentage of points obtained [57];

- 1 Star (Minimum Practice): 51% - 60%
- 2 Star (Good Practice): 61% - 70%
- 3 Star (Ideal Performance): 71% - 80%
- 4 Star (Exemplar Practice): 81% - 90%
- 5 Star (World Class): 91% - 100%

Many credits of BERDE are focused on minimizing resource consumption. In November 2017, BERDE Version 2.0 was launched during the annual PHILGBC National Convention that promoted more and more green buildings in Philippines. BERDE 2.0 Framework is focused on 9 categories, including [57]:

1. Energy Efficiency and Conservation
2. Water Efficiency and Conservation
3. Waste Management
4. Management
5. Use of Land and Ecology
6. Transportation
7. Green Materials
8. Indoor Environment Quality
9. Emissions

According to the World Risk Report 2018, Philippines has been ranked third in the world for having a high disaster risk with an index value of 25.14% (World Economic Forum, 2018) [59]. Nearly 60% of the lands of the country is prone to natural hazards, and 74% of the population is vulnerable to the effects. (GFDRR, 2017) [59]. This is mainly because of the geography and the coastal areas are always at risk for typhoons, storm surges and rising of sea level. The islands being located in “Ring of Fire” between the Eurasian and Pacific tectonic plates, makes the risk of earthquakes and volcanoes immense [59]. Apart from that floods and landslides are also occurring. (CFE-DM, 2018) [59]. Philippines has been affected by 565 disasters since 1990 which have resulted in great economic losses that is around $US 23 billion in damages (Jha, 2018) [59]. Nearly 50.3% of the total lands is estimated to be economically at risk and 85.2% of the production of the country is considered to be disaster susceptible. (ADB, 2012) [59]. Massive typhoons, such as Ondoy and Pepeng in 2009, Washi in 2011, Bopha in 2012, Haiyan in 2013, Koppu in 2015, Haima in 2016 and Mangkhut in 2018 are responsible for the greatest damages recorded. [59]. Due to the very high disaster risk profile of Philippines, local, international, government and private organizations have developed many guidelines and framework aligned with global frameworks such as Sendai Framework, Sustainable Development Goals & the Paris Climate Agreement, etc. But when it comes to integration of these DRR and disaster resilient mechanisms into the construction industry and BERDE green rating tool is very minimal. The only consideration it has been taken is that, during the predesign phase out of 6 phases of a construction project, (Predesign Phase, Regular Design Phase, Permitting Phase, Construction Phase, Permitting Phase, and Occupancy Phase, in chronological order) , it is determined whether the project is an Environmentally-Critical Project (ECP) or if the project site is an Environmentally-Critical Area (ECA) to determine if Environmental Impact Assessment (EIA) and Engineering, Geological, and Geohazard Assessment (EGGA) are needed to be conducted to comply with the requirements in securing Environmental Compliance Certificate (ECC) which is a mandatory requirement in the BERDE rating tool [57].

2.4 GREENSL® Rating Systems for Built Environment

Sri Lanka, known as the pearl of the Indian Ocean is a teardrop-shaped island adorned with breathtaking beaches, lush mountain ranges and greenery nestled further inland, is a center of attraction of many tourists from around the world. Being subjected to various developments over the past decades, especially the cities like Colombo, Jaffna, Kandy, Galle, Anuradhapura, Polonnaruwa and Hambanthota where the majority of the population resides are at the face of ecological destruction due to fast urbanization and industrialization that depletes the natural creations.[60].

Having inherited structures, monuments and irrigation systems that astonish the whole world from a proud history of 2500 years, Sri Lanka is familiar with green concepts. As a result of the emerging demand for greener concepts for the built environment, Green Building Council of Sri Lanka (GBCSL) was established in November 2009 as a not for profit organization that is striving to develop a building industry which is sustainable by promoting the green building practices [60]. The ultimate goal of GBCSL's endeavor is contributing to a life style that has coexistence with nature. The GBCSL is has been granted with the Emerging Member Status by the World Green Building Council. It operates with the vision of incorporating sustainable building construction practices to the construction industry of Sri Lanka aiming to flourishing the environment, prospering the economy and growing the society.

Sri Lanka has shown high tendency in the recent past to move towards energy efficient buildings and incorporate other green building practices into their building designs. GBCSL provides a specific framework and acts as the main governing body for green rated buildings in the country which did not exist in the past [37]. GBCSL has been actively involved in encouraging energy-efficient, eco-friendly and productive buildings since its establishment assessing over 100 buildings in the island. Some of the buildings include Hatton National Bank, Kalmunai which was awarded the platinum certification in Green Rating, Aliya Resort & Spa, Habarana, The CECB Headquarters (The first building rated by GBCSL), the National Archives and the World Trade Centre which was awarded the Gold Certification being the largest area (200,000m^2) greened so far [60]. This manifests that GBCSL is achieving its purpose of making Sri Lanka a sustainable country with the ultimate goal of healing the Earth. The main activities involve developing a rating system and managing it effectively to assess the environmental acceptability of the buildings. And it acts as a leader who strives to introduce green innovative solutions and integrate them to existing buildings while transforming Sri Lanka into a sustainable nation. According to the targets set by the GBCSL to be achieved by the year 2030, it is expected that at least 30% of the buildings in Sri Lanka will be carbon neutral buildings, 50% will be Green buildings with Platinum, Gold or Silver certification and 100% of the buildings are estimated to be at least green certified buildings [60]. If this could be achieved, a considerable energy saving will be possible. The adaptation of renewable energy and water efficiency techniques and the use of local manufacturing materials will reduce embodied carbon which would eventually results in a Greener Sri Lanka [60].

The Rating System had to be developed specifically for Sri Lanka to make it certain that sustainable greener practices are implied in constructing the buildings and the buildings are rated by experts in many different fields who have the authority and expertise to do so. Through the GBCSL the GREENSL® Accreditation Certificate is granted for the designers of buildings and it will be continuously followed up and monitored to crosscheck the quality and originality of the project deliverables throughout the process. Incentives will be provided from the Government to builders and the building solutions which achieve the benchmarks set by rating system. In the rating system scores are allocated to each aspect such as Materials, energy, quality of indoor environment etc. The Certifications will be awarded based on the following points system [37];

- Certified: 40–49 points
- Silver: 50–59 points
- Gold: 60–69 points
- Platinum: 70 points and above

All structures defined as Built Environments (offices, factories, commercial and institutional buildings, hotels and other residential buildings) are eligible to apply

for certification under the GREENSL® Rating System. There are 2 major GREENSL® Rating Systems which are namely [60],

1. GREENSL® Rating System for New Buildings
2. GREENSL® Rating System for Existing Buildings

Apart from the building tools GBCSL has been developing the following green certification rating systems [60];

1. GREENSL® Rating System for Cities
2. GREENSL® Rating System for Transportation Infrastructure
3. GREENSL® Rating System for Green Products (Green Labelling)

Under the literature review main focus is given to the GREENSL® Rating System for New Buildings considering the research scope. The motive is to encourage the increased performance, durable, cost effective, and environmentally friendly practices for buildings. GREENSL® Rating System for Built Environment concerns eight aspects with following points for each aspect [37];

1. Management (MN): 4 Points
2. Sustainable Sites (SS): 25 Points
3. Water Efficiency (WE): 14 Points
4. Energy and Atmosphere (EA): 22 Points
5. Materials and Resources (MR): 14 Points
6. Indoor Environmental Quality (EQ): 13 Points
7. Innovation and Design Process (ID): 4 Points
8. Social and Cultural Awareness (SC): 4 Points

Since there is a need of incorporating DRR and disaster resilient mechanisms and measures to GREENSL® Rating System for Built Environment for new buildings, let us look into the in-depth details about pre-requisites and credits using Table 5 [37],

Table 5: In-depth details about pre-requests and credits of the GREENSL® Rating System for Built Environment V 2.0 for New Building [37]

Prerequisite/Credit	**Criteria**	**Points**
1.0 MANAGEMENT (MN): 4 Total Points Available		
Prerequisite 1	Green Building Accredited Professional	Required
Prerequisite 2	Commissioning Clauses	Required
Prerequisite 3	Building users guide	Required
Credit 1.1	Building Tuning [1 Point]	
	Credit 1.1.1 Optimizing occupant comfort and Energy Efficiency	1 Point
Credit 1.2	Environmental Management [3 Points]	
	Credit 1.2.1 Involvement of Ecologist	1 Point
	Credit 1.2.2 Environmental Management Plan	1 Point
	Credit 1.2.3 Environment Management System (Complying with ISO 14001)	1 Point
2.0 SUSTAINABLE SITES (SS): 25 Total Points Available		
Prerequisite 1	Erosion and Sedimentation Control	Required

Credit 2.1	Site Selection	4 Points
Credit 2.2	Site Assessment and development	2 Points
Credit 2.3	Development Density and Community Connectivity	2 Points
Credit 2.4	Brownfield Redevelopment and allowance for connectivity of Green Lands	1 Point
Credit 2.5	Alternative Transportation [3 Points]	
	Credit 2.5.1 Public Transportation Access	1 Point
	Credit 2.5.2 Parking Capacity	1 Point
	Credit 2.5.3 Encourage use of green modes of transport	1 Point
Credit 2.6	Reduced Site Disturbance [6 Points]	
	Credit 2.6.1 Protect or Restore Habitat	2 Points
	Credit 2.6.2 Vertical greening	2 Points
	Credit 2.6.3 Development footprint	2 Points
Credit 2.7	Storm Water Design, Quantity Control	2 Points
Credit 2.8	Storm Water Design, Quality Control	2 Points
Credit 2.9	Heat Island Effect, Non – Roof	1 Point
Credit 2.10	Heat Island Effect, Roof	1 Point
Credit 2.11	Light Pollution Reduction	1 Point
3.0 WATER EFFICIENCY (WE): 14 Total Points Available		
Prerequisite 1	Eliminate potable water consumption for irrigation and landscaping	Required
Credit 3.1	Use of alternative water sources	1 Point
Credit 3.2	Use of water-saving performances	1 Point
Credit 3.3	Indoor water use reduction	1 – 4 Points
Credit 3.4	Water Efficiency in air conditioning system	1 Point
Credit 3.5	Innovative Wastewater Technologies [1-5 Points]	
	Credit 3.5.1: Reduce Potable Water Use	1 Point
	Credit 3.5.2: Reduce Potable Water Use or Treat Wastewater	1 Point
	Credit 3.5.3: Harvested rainwater	2 Points
	Credit 3.5.4: Aquifer Recharge	1 Point
Credit 3.6	Innovative Water Transmission	1 Point
Credit 3.7	Ground Water Recharge, if Ground Water Sources are Tapped	1 Point
4.0 ENERGY AND ATMOSPHERE (EA): 22 Total Points Available		
Prerequisite 1	Fundamental Building Systems Commissioning	Required
Prerequisite 2	Minimum Energy Performance	Required

Prerequisite 3	CFC Reduction in HVAC & R Equipment	Required
Credit 4.1	Optimize Energy Performance	1 – 10 Points
Credit 4.2	Renewable Energy	1 – 6 Points
Credit 4.3	Additional Commissioning	1 Point
Credit 4.4	Ozone Depletion	1 Point
Credit 4.5	Measurement & Verifications	1 – 2 Points
Credit 4.6	Green Power	1 Point
Credit 4.7	Certified Energy Auditor	1 Point
5.0 MATERIALS, RESOURCES & WASTE MANAGEMENT: 14 Total Points Available		
5.1 MATERIALS AND RESOURCES		
Prerequisite 1	Storage and collection of recyclables	Required
Credit 5.1.1	Building Reuse [1-2 Points]	
	Credit 5.1.1.1: Maintaining 75% of Existing Building Structure and Shell	1 Point
	Credit 5.1.1.2: Maintaining 75% of Existing Building Structure and Shell and 25% of Non-Shell Areas	2 Points
Credit 5.1.2	Resource reuse [1-2 Points]	
	Credit 5.1.2.1: for at least 10% of the Building	1 Point
	Credit 5.1.2.2: for at least 20% of the Building	2 Points
Credit 5.1.3	Recycled Content	1 Point
Credit 5.1.4	Local/ Regional Materials	1 Point
Credit 5.1.5	Rapidly Renewable materials	1 Point
Credit 5.1.6	Certified wood and other building materials	1 Point
Credit 5.1.7	Global Warming Potential of buildings	1 Point
Credit 5.1.8	Materials Produced with Waste materials	1 Point
5.2 WASTE MANAGEMENT		
Credit 5.2.1	Construction Waste Management [1-2 Points]	
	Credit 5.2.1.1: for 50% recycling	1 Point
	Credit 5.2.1.2: for 75% Recycling	2 Points
Credit 5.2.2	Operational solid waste management	1 Point
Credit 5.2.3	Hazardous Waste Management	1 Point
6.0 INDOOR ENVIRONMENTAL QUALITY (EQ): 13 Total Points Available		
Prerequisite 1	Minimum IAQ Performance	Required
Prerequisite 2	Smoke (ETS) Control	Required
Prerequisite 3	Minimum Acoustic Performance	Required

Credit 6.1	Outdoor air delivering Monitoring	1 Point
Credit 6.2	Increased Ventilation	1 Point
Credit 6.3	Construction IAQ Management Plan	1 Point
Credit 6.4	Low- Emitting Materials [1-3 Points]	
	Credit 6.4.1 Paints and Coatings	1 Point
	Credit 6.4.2 Carpet Systems	1 Point
	Credit 6.4.3 Composite Timber and Agrifibre Products	1 Point
Credit 6.5	Indoor Chemical & Pollutant Source Control	1 Point
Credit 6.6	Controllability of systems [1-2 Points]	
	Credit 6.6.1 Lighting controls	1 Point
	Credit 6.6.2 Comfort controls	1 Point
Credit 6.7	Thermal comfort, design	1 Point
Credit 6.8	Thermal comfort, verification	1 Point
Credit 6.9	Daylight & Views [2 Points]	
	Credit 6.9.1 Daylight	1 Point
	Credit 6.9.2 Views	1 Point
7.0 INNOVATION & DESIGN PROCESS (ID): 4 Total Points Available		
Credit 7.1	Innovation in Design [1-4 Points]	
	Credit 7.1.1 Innovation in design	1 – 2 Points
	Credit 7.1.2 Exemplary Performance	1 – 2 Points
8.0 SOCIAL & CULTURAL AWARENESS (SC): 4 Total Points Available		
Prerequisite 1	Archaeological sites & Heritage buildings	Required
Credit 8.1	Social Wellbeing, Public Health & Safety	1 – 2 Points
Credit 8.2	Cultural Identity	1 – 2 Points
Total Number of Points		100

Before incorporating or integrating the DRR and disaster resilient mechanisms and measures to the GREENSL® Rating System for Built Environment for new buildings, first let’s look into how much and for what extend the DRR and disaster resilient mechanisms have been incorporated or integrated into the existing pre-request and credits of the same green tool by GBCSL [37] through Table 6.

Table 6: DRR and Disaster Resilient Mechanisms Incorporated in to the GREENSL® Rating System for Built Environment for New Buildings Version Rating Tool [37]

Main Category	Sub-Category (Pre-request/ Credit)	DRR Measure
Sustainable Sites (SS)	Credit 2.1: Site Selection	• Land whose elevation is lower than 1.5m above the elevation of the 50-year flood level • Land which is prior to acquisition for the project was public parkland or land identified as landslide-prone areas.
	Credit 2.2: Site Assessment and Development	Hydrology: Flood hazard areas, delineated wetlands, lakes, streams, shorelines, rainwater collection and reuse opportunities, TR-55 initial water storage capacity on site

2.5 Disaster Risk Reduction (DRR) Mechanisms and Disaster Resilient Local Guidelines

After a better understanding about DRR and disaster management basics, global guidelines and frameworks about DRR and green rating tools including GREENSL® rating system for built environment, now let's look into the DRR mechanisms and disaster resilient local guidelines. When it comes to DRR mechanisms and disaster resilient local guidelines, they can be divided into two major aspects as;

1. Structural (Hard) DRR Measures
2. Non-Structural (Soft) DRR Measures

2.5.1 Structural (Hard) DRR Measures

The structural measures that are normally applied for DRR in the global context and local guidelines for disaster resilience will be discussed. Hard DRR mechanisms for buildings are considering structural performance, material performance and impacts of contamination. Structural or hard DRR measures are listed under the following natural hazards;

a) Structural (Hard) DRR measures for Floods
b) Structural (Hard) DRR measures for Landslides
c) Structural (Hard) DRR measures for Heavy Winds

a) Structural (Hard) DRR Measures for Floods

Following are some of the local and global structural DRR measures and disaster resilient local guidelines for the following floods hazards;

- **Building Plan, Orientation and Placement of Openings**

First, identifying the flood zone and the obtaining the greatest flood level record in the selected land is mandatory. Data can be obtained through available resources. (Irrigation Department data etc.). As the next step, the flooding direction will be identified. Next task is planning the building with its orientation in a mannar where short edge of the building is placed to face the flooding direction as in Figure 8. Also, openings on opposite walls must be aligned to each to generate a flow path for storm water as demonstrated in Figure 9 [61].

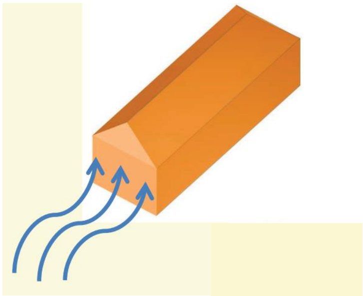

Figure 8: Shorter Side of the Building is Oriented to Face the Direction of Flooding [61]

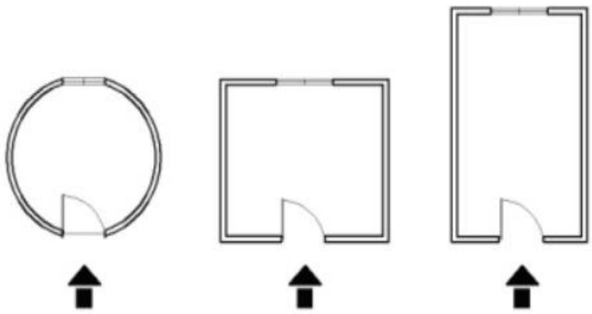

Figure 9: Placement of Openings in the Buildings, creating a flow path for water [61]

- **Foundations of the Flood Resistant Buildings**

Slabs and foundations made of concrete play a major role in withstanding natural disasters. For problematic sub soil conditions pile foundations are suggested. Buildings should be erected on soil strata that are not susceptible for liquefaction due to flooding. Depth of foundation should be maintained as follows [62];

1. The column footings shall be lowered minimum 1.0 m below finished grade.
2. Wall footings shall be lowered minimum 0.6 m below grade.

Also, for the risk of the ground floor getting flooded, flood barrier walls shall be suggested. [62].

- **Elevated Buildings**

Elevated buildings are mainly of two types as explained below [61];

1. The floor elevation is raised by increasing the plinth either by building on a higher ground as shown in Figure 10 or by creating an elevated ground as shown in Figure 11. The plinth height shall be minimum 150mm above the highest recorded flood level in the region.
2. The building is constructed on silts where the silts are raised up to minimum 150 mm above highest recorded flood level in the region and the maximum unsupported height of silts cannot exceed 3 m. Otherwise an intermediate tie beam shall be provided as shown in Figure 12.

In both of the above options, the highly occupant areas of the buildings are encouraged to be designed above the Base Flood Elevation (B. F. E.). The building is erected on suitable supports to withstand the weight of the structure and flood water forces and facilitate space for the flow of flood water. The space below the occupant areas or BFE, is encouraged to be employed for parking, as laundry or bathroom etc. If the arena has low occurrence of floods, existing buildings that are impossible to elevate will be retrofitted to be disaster resilient. Utilization of basement infills and flood openings effectively are two of the retrofitting mechanisms implied in managing storm water.

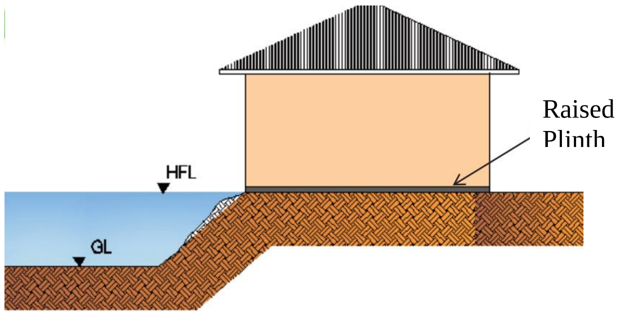

Figure 10: Plinth Level Raised by Building on Higher Ground [61]

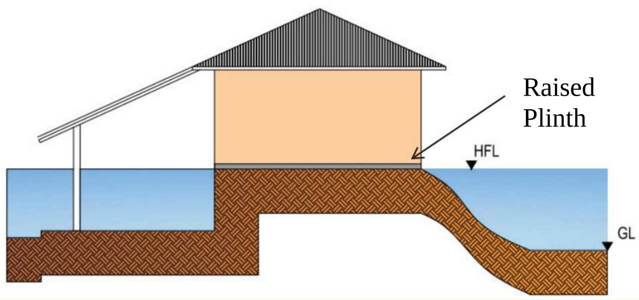

Figure 11: Plinth Level Raised by Creating an Elevated Ground [61]

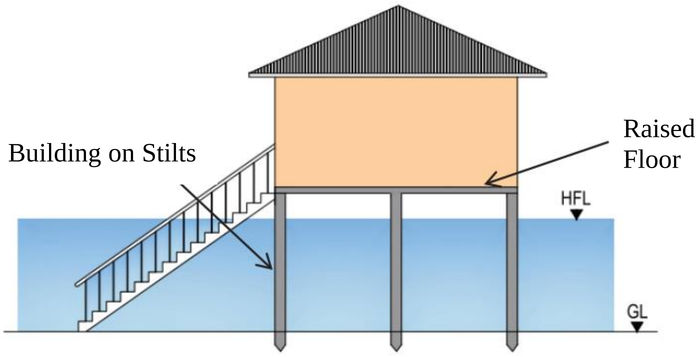

Figure 12: Plinth Level Raised by Building on Silts [61]

- **Building Superstructures**

Cross walls are one of the most common superstructure types applied in buildings to combat floods which walls are constructed against or perpendicular to the flood flow. As shown in Figure 13, it is highly encouraged to construct buildings in a manner where cross walls are placed inside the building to facilitate this while having at least a minimum of 4 reinforced concrete columns at the four corners of the building for strengthening purposes. An additional intermediate column is required for wall lengths exceeding 6m, along that wall. (especially for walls in the coastal areas). Walls are advised to be made heavy and the hollow blocks should be 200 mm thick. Solid block work or brickwork is recommended for 100 mm thick walls to provide good thermal insulation and protection from rain. When it comes to the openings of the walls, specially, the aggregates used for constructing the wall openings such as doors and windows, aggregate width should not be greater than 50% when compared with wall width [61].

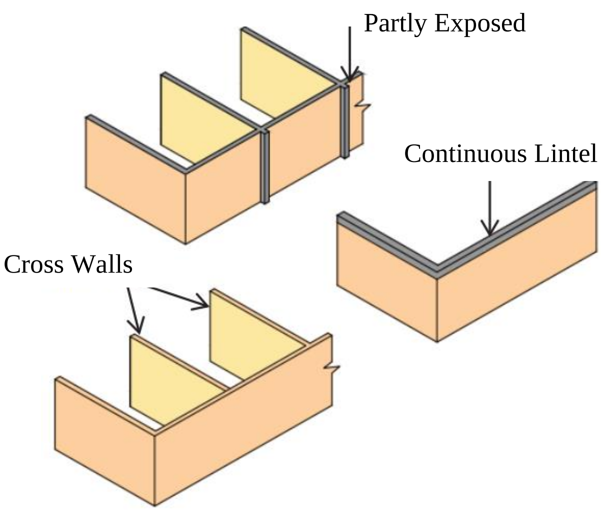

Figure 13: Cross Walls [61]

- **Amphibious Buildings**

An amphibious building normally floats on the flood water, rises with the flood water level and comes back to its original position as the flow reduces. Hence it can be used in both land and water [65]. They are commonly constructed as residential buildings across the globe. The two main types of amphibious buildings are namely, boat type and lift type [65].

I. Boat Type Amphibious Buildings: This type of floating building can freely move in both vertical and horizontal directions. The floor of the building is designed to be water tight so the water does not enter from the base to the floor area. The building has an anchor system to stop the house to dislocate from its original position with the flow of water [65].

II. Lift Type Amphibious Buildings: These buildings can freely move only in vertical direction in a controlled way along with the rising water level in a flood situation. The building cannot move in horizontal direction because of the guiding columns at the corners. Until the flood water lifts the building up by buoyant forces the building stays on the ground surface.

Both types of buildings should have suitable bases and an adequate buoyant force to start the movement. The foundations used in these houses are called buoyant foundations. Buoyancy blocks have to be provided underside of the house for lifting house up in case of flood and they are normally made using recycled materials. [65].

- **Flood Proof Construction Materials**

It is recommended to use more robust, durable, strong, energy efficient, fire resistive and versatile material in construction. Concrete as a material that does not rot or rust is suitable for building construction to withstand floods. [62]. Also, it has the required hardness and it is heavy enough to withstand the effects from the high winds and debris and it is also fire resistive. [62]. For severe floods reinforced concrete framing systems have been designed [62]. For making internal walls water resistant, concrete block partitions, lime plastering or using magnesium oxide board as finishing can be adopted [62]. Construction materials must be of good quality as they need to withstand the imposed immoderate loads on them. Blocks are preferred not to be used until one month has elapsed from casting. That is to ensure when the block has been located in the wall, shrinkage is almost over. Following are few of the standard minimum mix proportions (cement: sand) to be maintained for some of the construction scenarios;

- Binding Mortar – 1:6
- Cement Blocks – 1:10

- **Wall to Floor Junction in a Building**

As a major point from where water leaks inside a building, this wall to floor junction is recommended to be water resistive. Either designing of two layers of waterproofing which involves water tanking below the slab to withstand water pressure (primary layer) and a cavity drainage for water collection after flood (secondary layer) [65] or utilizing a waterproof concrete with two waterproofing layers (primary layer consists of a concrete slab and wall with water resistant additives and the secondary layer consists of a cavity drainage generally) [65].

- **Wet Flood Proofing Technique**

Here safe flow of water is allowed through the bottom layer of the building [66]. Buildings can resist storm water up to an extend of 600mm. After exceeding that limit, water will enter into the building to minimize pressure created on the building. If the sewer and the water conveyance systems are not properly sealed or water proofed, it is recommended to place them above the water level to prevent health problems. Also another remedy for the above issue will be the installation of a non-return valve for sewers and drainage pipes for water sealing or proofing purpose. It is recommended to fix anti-lift lids together with inspection chambers. Another recommendation under wet flood proofing is to seal or elevate the service entry points, fire protection systems and equipment and electrical appliances and their outlets based on the design flood levels of the building. If not, it is recommended to install units and appliances manufactured with waterproof materials which are below the flood level.

- **Water Proof/Tight Construction (Lower Levels)**

The openings and walls will be sealed for avoiding water penetration into the building and the sealing should be able to withstand the lateral flood forces as well as the uplift thrust force. All these forces should be taken into account when designing. Materials like enclosures, membranes, sealants and coatings will be useful in making the lower level water tight. It is favorable if flood resistant doors can be fixed as they can block the storm water entering the building premises during floods [61][65].

- **Post-Flood Drainage Systems**

Drains, channels and pipes are there in the floor/ground to drain off storm water during a flood condition or collection of excess water. Drain connections can be fitted at the man holes using non-return valves and anti-lift lids. Pipes are fitted with non-return valves to avoid back flow of water. Natural ventilation and also a Mechanical Ventilation Heat Recovery system is recommended to support the quick drying after flooding. [65].

- **Health Monitoring and Maintenance of the Building**

Conduct relevant structural health monitoring checks for the building in recommended time intervals (usually annually) under proper monitoring and targeting building resilience against natural hazards.

b) Structural (Hard) DRR Measures for Landslides

Following are some of the local and global structural DRR measures and disaster resilient local guidelines for the following landslide hazards;

- **Site Selection**

Site suitability with regard to landslide potential is not judged purely based on the characteristics of the site alone, but includes a broader spectrum of areas related to the location and placement of site. The site should be selected after a sound land assessment and its surroundings to identify the level of risk of the selected site from landslides. A site selected to construct a building shall be not containing features regard to landslide threats or unstable slopes. Thus, the site should be located with a sufficient distance from such risky areas and features. Areas which are unsuitable for buildings can be identified using Landslide Hazard Maps. Also, when selecting a safe land for construction, identification of the Ground Slope Suitability using the below ground or land stabilization slopes is a vital requirement [61];

I. Slope < 5^0 - Suitable for construction
II. 5^0 < Slope < 31^0 - Apply necessary engineering techniques
III. Slope > 31^0 - Not suitable for construction; can use for agricultural purposes

Also, it is recommended that the building shall be constructed at a sufficiently safe distance away from the toes of slopes. The distance needed from the slope to the building has to be designed appropriately by the engineer. Proper planning for utilizing adequate space for access roads, site offices with facilities, sewage disposal and cut and fill of land is mandatory at the planning stage [61].

- **Building Layout, Orientation and Shape**

In planning the building layout, orientation and shape, proper attention should be given to reduce the disturbances from excavation and cutting to prevailing slopes and foundations. The layout of the building with adequate internal spaces should be properly planned. On mild slopes the buildings can be built on a levelled formation on the natural ground [61]. Longer sides of the buildings on a single platform should be parallel to the natural contour lines of the slope to avoid meeting huge differences in sub soil conditions and minimize cut and fill work. When it comes to the building shape, simple and symmetrical shapes such as square or rectangular shapes are recommended for the purpose of minimizing negative effects from ground movements or disturbances [61].

- **Earthworks**

All cut and fills for preparation of site, access roads, excavations must be designed to ensure safety and stability during and after construction. Depending on the soil type and factors like the height of cut and the slope protection method the permissible slope angle will vary. Though in competent bedrocks steeper slopes are allowed, in weathered rocks the weathering conditions, dipping, joint sets of the rock will affect the slope. The stable cut slopes in different soil types (with or without a retaining wall) shall be utilized as shown in Table 7 [61].

Table 7: The Stable Cut Slopes in Different Soil Types with or without a Retaining Wall [61]

Type of Soil/Rock	**Stable Cut Slope (Vertical: Horizontal)**	
	without Wall	with Wall
Soil or soil mixed with boulders and		
a) Dense vegetation b) Less vegetation	2:1 1:1	5:1 3:1
Hard rock, shale or harder rock with		
a) Inward dip b) Outward dip	4:1 to vertical 2:1 or dip angle	Vertical 5:1

Maximum height of the vertical cut to be restricted depending on the land slope and soil type [61];

I. Ground slope between 11^o - 17^o: 1.5 m for residual soil and 1.0 m for colluvium soil
II. Ground slope between 17^o-31^o: 1m for residual soil and no unsupported cuts in colluvium soil

Minimum horizontal distance to the proposed building from the toe of the vertical cut to be restricted [61].

I. Ground slope between 11^o - 17^o: 2 m
II. Ground slope between 17^o - 31^o: 3 m

Sufficient safe space should be provided the cut slope toe and the building. The safe distance (d) between the cut slope toe and the building varies with the height of cut and the availability of a retaining wall. The distance (d) of free-standing cut slopes shall be of the same height (H) of the cut slope as shown in Figure 14 [61].

Maximum permissible horizontal distance from the top of the vertical cut to be greater than the height of the cut (H) or if there is a retaining wall, the distance (d) should be the same as the height of the retaining wall or building [61] as shown in Figure 15.

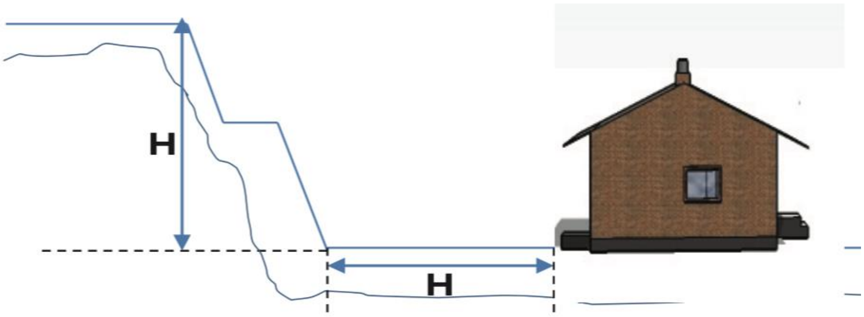

Figure 14: Height of the cut slope is equal to the distance between building and cut slope [61]

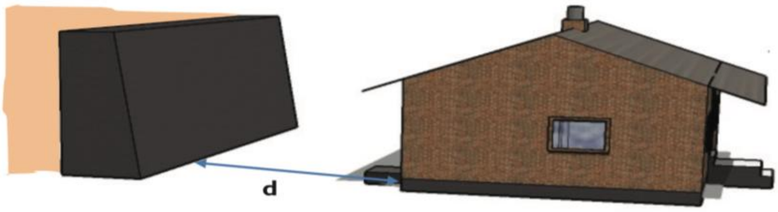

Figure 15: Relationship between height of the retaining wall and the distance between retaining wall [61]

- **Foundation of the Building**

The building foundations together with their structures should be located away from unprotected, natural or manmade slopes. The bottom of the footing is preferred be located below the prevailing ground level or the finished ground level according to what is smaller, including on the cut or filled part referring to minimum depth requirements. The size and depth of foundation should be decided based on the type of subsoil and the bearing capacity of the soil where the building is constructed. Also, footings on sloping grounds shall be constructed with enough edge distance for protection against erosion.

- **Construction of suitable earth retaining structures & other slope stabilization techniques**

Near vertical steep slopes, soil can be unstable and hence an external support should be provided through a suitable retaining wall. The common types of retaining walls are;

a) Retaining Walls (Gabion walls and Crib walls) - mass concrete or random rubble masonry
b) Reinforced Concrete Walls
c) Embedded Walls (steel sheet piles, Diaphragm walls, contiguous bored piles)
d) Soil nailing and anchoring
e) Grouted bars

- **Development of properly designed surface & sub-surface drainage networks along the slopes**

Many landslides in Sri Lanka have taken place due heavy storms and continuous rainfalls. Rains contribute to a greater amount of soil erosion on a slope while infiltrating the storm water into the soil to fill the voids. This will result to reduce the matric sadiron of soil and saturates it with more weight. As a result, the ground water level will be rise and soil strength will be reduced. If there is poor drainage even a stable slope can fail suddenly. Thus, it is vital to manage both surface and subsurface drainage networks.

Natural drainage paths should not be disturbed by construction and rain water, water from springs and treated waste water should be directed away from the slope into natural water bodies or to storm or waste water drainage systems. Following measures can be adopted for designing, developing and managing a network of surface drainage.

a) Provide interceptor drains to collect and divert runoff and springs to prevent surface flow within any unstable or cleared area.
b) Provide diversion drains to prevent water flowing into any unstable or cleared area across its periphery.
c) Provide silt traps / silt fence to prevent blockage of drains due to siltation.
d) Line the trenches and channels to minimize erosion.
e) Utilize flexible material or flexible joints if pipes are used to drain water.
f) Provide structures to dissipate energy and reduce the flow velocities in channels.
g) Provide adequate reservation for existing natural streams or drains.
h) Provide culverts, concrete pipes etc., as required for access or internal road crossings.
i) Provide adequate flow capacity and slope and drops in all drains, channels, pipes etc., to prevent blockage.

When it comes to sub-surface drainage system, it is essential to design, develop and well maintain a sub-surface drainage network due to the rising of ground water table because of heavy rains will cause instability in cut slopes. So, following measures are recommended to control groundwater flow or seepage.

a) Intercept the groundwater and properly divert it away from the land using a French drain or subsurface drains. French drain consists of a perforated hollow pipe wrapped around with a filter of geotextile fiber and surrounded by permeable material such as sand and gravel packed within a lateral trench. The pipe should have a proper gradient and an outlet to a suitable surface drain for the intercepted water to flow away swiftly. These drains are more suited when the groundwater rises to within about1.5m from ground surface as deeper excavation could be costly.

b) Provide sub-surface drains in to help lower the ground water table and prevent build-up of hydrostatic pressure against the walls.
c) Adequate number and area of weep holes are provided.
d) Pipelines used for construction of all subsurface and diversion drains are of flexible materials and with flexible joints provided to accommodate ground movements and to prevent breakage and leakage
e) Manholes are provided at appropriate locations for maintenance.
f) Surface runoff is diverted separately preventing inflow of surface water in to sub-surface drains

- **Landslide resilient construction techniques**

When there is a moderate ground slope, the building can be made terraced with stepped floor levels and built on platforms at different levels as it matches with the ground slope profile as shown in Figure 16 [61]. Through this, the disturbances to the ground and earthworks can be considerably minimized. An elevated structure on pillars or raised footings on natural ground as it causes minimal disturbance to the slope can be designed as shown in Figure 17 [61].

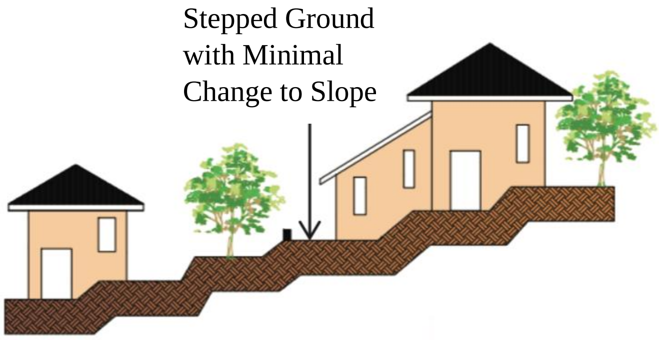

Figure 16: Terraced Building [61]

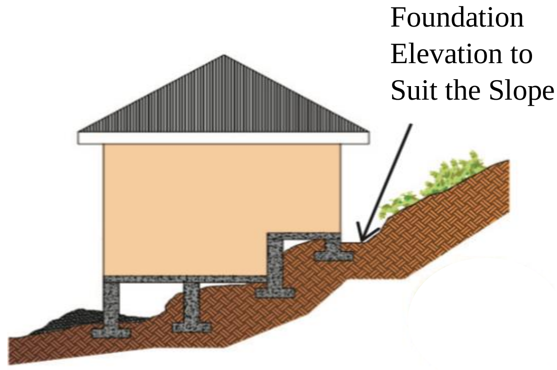

Figure 17: An elevated structure on columns or raised footings [61]

- **Health Monitoring and Maintenance of the Building**

Conduct relevant structural health monitoring checks for the building in recommended time intervals (usually annually) under proper monitoring and targeting building resilience against natural hazards.

c) Structural (Hard) DRR Measures for Heavy Winds

When the wind is blown through an obstructing object, the wind direction gets changed slowing down its speed. Pressures can be created because of that and they can act on the obstruction in positive or negative manner. The load resulting from high speed winds are greater and such lateral wind forces on buildings will create pushing forces which will result in following actions on buildings.

a) Uplift - wind flowing over the roof of the house can create a lifting effect
b) Sliding - horizontal wind pressure can cause the house to slide off its foundation
c) Racking - horizontal wind pressure can cause tilting of the house
d) Overturning- wind can cause the walls to rotate off the foundation.

A building that is not properly designed to resist high winds can experience damages to its structural components depending on the severity of the wind. General patterns of damage include separation of structural components or breakage of members.

Following are some of the local and global structural DRR measures and disaster resilient local guidelines for the following high/heavy wind hazards;

- **Site/Land Selection**

Refer Wind Loading Zones Maps & identify the expected average wind speeds [61] for a return period of 50 years before planning and designing the building as listed and mapped in Figure 18;

I. Zone1: 50 m/s
II. Zone 2: 42 m/s
III. Zone 3: 38 m/s

Select a location or a land where there is no wind blowing directly to the structure. In unavoidable situations, the building should be sheltered either with permanent shelter or temporary shelter using other structures or trees which will act as a barrier for wind. In hilly terrains, the building should be located in a valley, but considerably away from strong wind ways. [61].

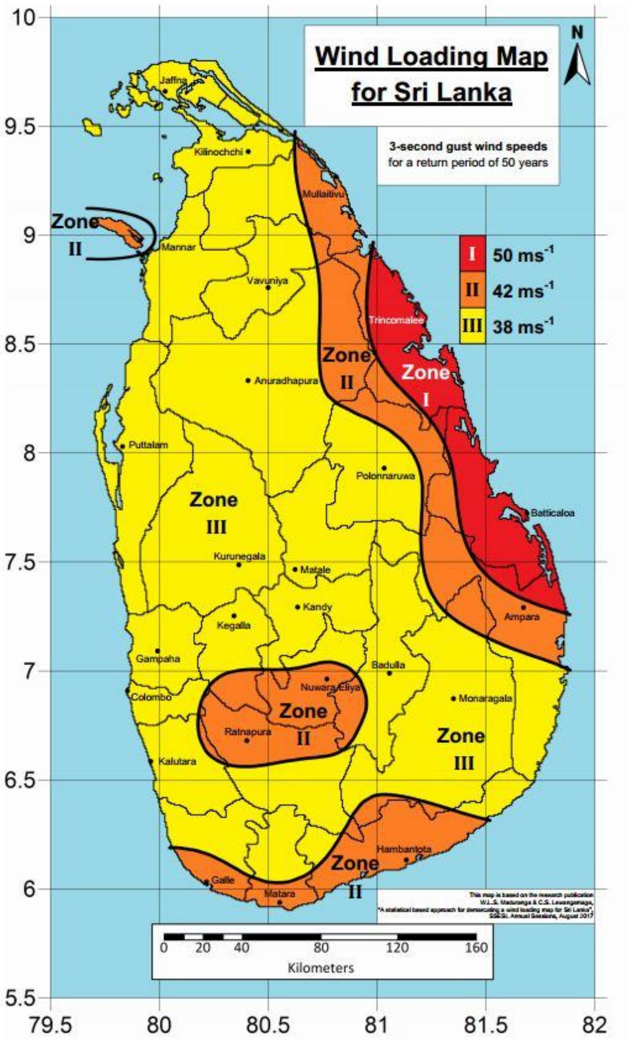

Figure 18: Wind Loading and Zonation Map of Sri Lanka [13]

- **Building Layout, Orientation and Shape Arrangement**

The layout of the building with internal spaces of the building should be planned as a simple system. At least one small room should be serving as a safe refuge from high wind situations and cyclones. The orientation of the house should be planned to affect from a minimal wind force. As shown in Figure 19 a rectangular structure can be designed as their shorter sides face the critical wind direction at a wind tunnel scenario.[61].

The shape of a building plays a main role in separating the wind as well as withstanding the magnitude and the distribution of the forces acting. It is recommended to avoid irregular shapes as much as possible while selecting simple shapes that may offer better stability under wind loads [61]. building openings are advised to be designed on opposite walls to create a flow path which allows the wind flow as shown in Figure 20 [61].

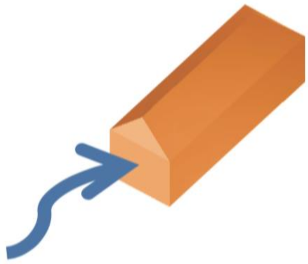

Figure 19: Shorter Side of the Building Facing Wind Direction [61]

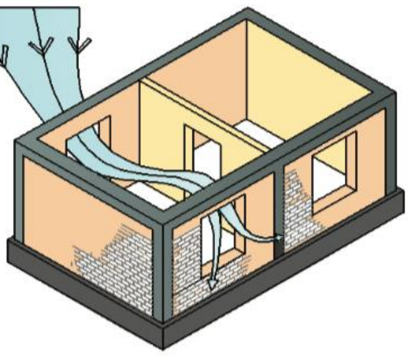

Figure 20: Openings on Opposite Walls Creating Flow Path [61]

- **Walls**

It is recommended to follow and practice the following guidelines for providing strengthened walls to withstand lateral wind forces.

a) Walls shall be supported on all four sides with columns and beams to provide a stiffer wall.
b) Height of double brick panel block walls shall not be more than 3 m and single panel brick walls shall not be more than 2.4 m.

- **Doors**

Door frames shall be provided with adequate connection to the walls on either side as follows;

a) Nail galvanized iron straps to door frame with gauge flat head nails.
b) Iron strap to be made from gauge galvanized iron bent and folded
c) Brickwork to be built up around the door frame as shown in Figure 21.

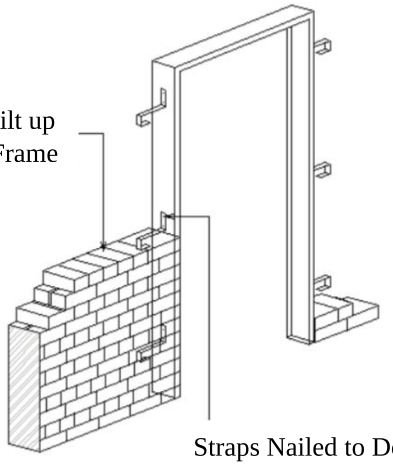

Figure 21: Brickwork Construction around the Door Frame [61]

- **Roof Structure**

Separation of wind flow at the buildings may cause negative pressures at some locations. Damages can be caused to the roof from these suction forces. It is better to avoid mono-pitch roofs should in high wind areas. Also, when comparing the different roof types, hipped roofs have more performance in resisting wind forces than gable roofs.

Roof connections between Rafter, wall plate, Reeper, Ridge Board, Under-purlin & at Roof Edges (Barge and Eaves) should be properly chosen, designed and fixed according to standard guidelines based on the wind load, wind zone, building height and number of stories, etc. to increase the strength of the roof structure against high winds. Reinforced concrete flat roofs can be utilized to provide greater resilience to high winds and specifications are as follows;

a) Roof slope shall be > 1:100.
b) Maximum overhang shall be in accordance with the minimum requirements.
c) Reinforced concrete slab shall be designed with a standard minimum thickness and be constructed with 25 MPa concrete and shall include a reinforcing wire mesh.
d) Roof slabs shall be provided with proper water proofing.
e) All vertical reinforcing bars in the vertical components of the structure shall be bent and extended into the slab at least 450 mm overlap and tied to the slab reinforcement with binding wire.

- **Health Monitoring and Maintenance of the Building**

Conduct relevant structural health monitoring checks for the building in recommended time intervals (usually annually), under proper monitoring and targeting building resilience against natural hazards.

2.5.2 Non-Structural (Soft) DRR Measures

There is no measure found to eliminate risk totally. In many areas that are prone to disasters, adequate hazard mitigation techniques cannot be found. An optimal, site-specific mix of structural and non-structural measures is being sought. Some soft DRR measures and guidelines to be introduced into the green rating systems are discussed below.

a) Input a section which is provided to qualify as a Green Building Accredited Professional (GBAP) as well as a compulsory module for university students in all higher education institutes in Sri Lanka. The assigned GBAP should use his expertise knowledge on green building & sustainability concepts together with DRR & disaster resilience aspects in the project. Above GBAP should have the expertise knowledge on green building & sustainability concepts together with DRR & disaster resilience aspects as well. In achieving the above criteria, existing green accredited professionals will be trained with a new short course about DRR. For future GBAPs, a new module about DRR & disaster resilience will be introduced to the curriculums of the Associate Professional Training (APT) program and advance training program as well to qualify as a GBAP.

b) A separate section/chapter about emergency handling mechanisms during a hazard (including fire hazard) should be incorporated in to the building user guide [46].

c) Develop an emergency preparedness information and instructions manual for apartment occupants, home residents, commercial and other building occupants with the building contact directory [46]. Above manual should include the following sections [69],

    - Introduction to the manual
    - Applicable Vulnerable hazards and scenarios
    - Critical Operational Functions, Systems, and Supplies
    - Roles and Responsibilities during a hazard or an emergency
    - Coordinating/Integrating during a hazard or an emergency
    - Evacuation plan (routes, Shelters and stakeholder involvement, etc) including evacuation of disable and people with special health needs during an emergency
    - Building contact & safety directory including all emergency contacts
    - Model emergency operating procedures
    - Training and Education
    - Recourses and references

d) Implement sediment and erosion control plan which also will reduce the risk of occurrence and damage due to natural hazards as follows [63][65];

- Plant trees for erosion control which have a root system effective at holding back soil as a special strategy for landslide prone areas and trees act as a barrier against heavy winds.
- Conduct terracing, contour ploughing and other identified techniques
- Management of vegetation cover afforestation for watershed management where as it controls formation of floodwater which includes land use and soil conservation to minimize surface runoff, erosion and sediment transport.

e) Avoid constructions in inappropriate sites to reduce the vulnerability from natural hazards and carryout site assessment on following [37][43];

- Use Hazard Maps and identify the vulnerable hazards and vulnerability level of the site for floods, landslides. Heavy winds and Tsunamis.
- Topography - Contour mapping, elevation of the land can indicate whether the land is vulnerable to floods or landslides
- Hydrology - Proximity to drainage paths, waterways, water bodies, lakes, streams, shorelines, delineated wetlands, marsh-lands, coastline and initial water storage capacity of the site would suggest potential of flood hazard areas.
- Access the level of vulnerability in brownfield lands for probable hazards improve the resilience of the brownfield site using mechanisms such as, implement a mechanism to treat soil onsite and avoid removal of contaminants to reduce environmental impacts and thereby
- Introduce green remediation strategies to improve the resilience of the brownfield site such as application of more ecofriendly, safe and sustainable cleanup practices that lessen the overall adverse environmental impacts crated through the cleanup phase of brownfield revitalization mechanisms.

f) Identify the transportation needs of the people in case of an emergency for the required sites which are vulnerable to hazards only by allocating required transportation facilities, resources and alternative evacuation routes to be used during an emergency to evacuate people especially for the buildings situated in vulnerable sites [46].

g) Enhancing the connectivity of community and transportation needs during an emergency through building alternative connections/connectivities by networking with other communities [46].

h) Limit disruption of natural water hydrology through watershed management technique which addresses the groundwater formation which involves soil conservation practices to reduce surface runoff, erosion and transportation of sediments. [68].

i) Provide access to public portable water transmission systems and wastewater conveyance networks during emergency situations by creating secondary facilities, redundant transmission-distribution pipelines or multiple water storage facilities with emergency(uninterruptible) power supply at pumping stations to prevent service disruption during a blackout [46].

j) Rain water management systems should be adopted based on the future climate predictions and rain fall patterns (In order to adopt for climate change). [63].

k) Installation of storm water collection and storage systems combined to rain water harvesting tanks which can handle greater capacities, intensity and precipitation especially in flood prone areas and other areas as well within the transportation infrastructure (road pavements), other infrastructure facilities, commercial and residential buildings. [37][46].

l) Design HVAC systems based on future climate changes and temperature variances, highlighting the energy resilience and natural hazards aspect.

m) All buildings in disaster prone areas shall use backup & emergency power sources and reliable communication systems [46].

n) Install a wireless fire communication system to all large buildings in hazard zone areas as a backup system; especially vulnerable to flood hazards while providing backup phone and data connections to all the critical buildings such as hospitals and schools, etc.

o) Always store storage batteries (at least with a life of eight hours) to function the buildings' fire and life safety communication systems [46].

p) Use 100% of renewable energy sources such as cogeneration & solar as reliable backup & emergency power sources to be used during blackouts by removing barriers to solar energy and increase the allowable roof areas and possible ways to obtain solar power. Keep Commercial & Residential Building Stairwells, Hallways and emergency exits Lit during blackouts due to natural hazard using solar energy and other reliable renewable energy sources. (According to Fire Regulations by CIDA & By Laws for the fire protection and detection by CMC)

q) Take appropriate measures to safeguard toxic waste collected and hazardous materials stored in flood prone zones by storing them in a flood proof area or above the elevation of the 50-year flood level which water can't be reached [65].

r) Install an emergency lighting control system to keep commercial & residential building stairwells, hallways and emergency exits lit during blackouts due to natural hazard using generators or other reliable energy sources [46].

s) Emergency & First aid Kit to be stored in first floor to be used during an emergency may contain items such as, water bottle, flashlight (crank or battery-powered and Replace batteries once a year.), emergency operation manual with emergency contacts, a whistle, candles, a match box, and first aid kit, etc. [46][69].

t) Design open public spaces in disaster risk areas and in vulnerable building premises which may be in greater elevations to minimize the risk of floods where public can be gathered in an emergency situation [46].

u) Evacuation routes are developed as a part of public transportation systems for emergency management planning which leads to use Pedestrian Paths & Sidewalks as evacuation routes during emergencies and hazards [46].

v) Introduce flood and landslide warning systems with sensors in order to detect the disaster incidents.

w) Awareness programmes for general public on natural disasters and their mitigation measures along with techniques related to preparedness.

x) A tailored resource base is available to support disaster management plans in hazardous situations [46]:
   - Institutional capacity
   - Human resources (diverse stakeholders)
   - Applicable set of effective policy
   - Financial capacity
   - Technical capacity
   - Empowered local leadership

y) Inputs for investing in disaster resilience by the local businesses and corporate citizens as a part of their corporate social responsibility are recognized and supported by the local authorities while introducing potential disaster risk transfer mechanisms for the corporate citizens / businesses of the cities. Also, introduce business continuity plans that address disaster risk are available for the corporate citizens / businesses in the city at all scales [46].

z) Hazard risk in land profiles are incorporated into land pricing [46].

3 METHODOLOGY

To achieve the defined objectives of the research work, a methodology was phased out under seven segments as follows;

1. A Comprehensive literature review on introduction to natural hazards and DRR, Green Rating Tools, Global & Local Frameworks & Guidelines
2. An in-depth desk study to identify the structural and non-structural DRR mechanisms for floods, landslides and heavy winds
3. Development of Guidelines (Structural & Non-Structural) & Incorporation of them under the existing 8 categories of the Building tool of the GREENSL® Rating System
4. Evaluation of the incorporated guidelines under existing 8 categories of the Building tool of the GREENSL® Rating System using an expert committee meeting
5. Awarding of credits to the developed rating tools and evaluation of the credited rating tools of the GREENSL® Rating system using the same expert committee
6. Applicability evaluation and validation of the developed rating tools of the GREENSL® Rating system

The information under the segment 1 and 2 which are the literature review and in-depth desk study are listed and discussed under Chapter 2, “Literature Review”. Therefore, rest of the 5 segments will be discussed under this Chapter.

3.1 Development and Incorporation of Guidelines

Under this segment, DRR and disaster resilient guidelines were developed using the data and information collected under the literature review. Then the developed guidelines were incorporated into the existing 8 categories of the Building tool of the GREENSL® Rating System. Incorporated guidelines can be categorized depending on the level of incorporation to the existing tool as follows;

I. Level 01: Guidelines are incorporated as a new subcategory
II. Level 02: Guidelines are incorporated as a new sub-prerequisite or a sub-credit under the existing credits and prerequisites
III. Level 03: Guidelines are incorporated as a new minor improvement or an amendment done to sub-prerequisites & sub-credits

Building tool with the above incorporation types are attached under the Annex 1. All the added guidelines and amendments done to the existing building tool are marked and written in red color for easy and clear reference. But for better explanation about development and integration of guidelines under above incorporation levels, three examples will be taken under each incorporation level and explained in this chapter.

When it comes to level 01 type, two new sub-categories were developed under the existing eight categories through integrating the guidelines. Those two new sub-categories are as follows;

a) A new prerequisite as ‘Prerequisite 4’ was introduced to the first category, ‘Management’ which is named as, “Emergency Preparedness Information and Instructions Manual”.
b) A new credit as ‘Credit 5.1.9’ was introduced to the fifth category, ‘Materials, Recourses and Waste Management’ which is named as, “Hazard Resilient Building Materials”.

For better explanation about the development and integration of guidelines under level 01 as a new sub-category, ‘a)’ will be taken as the Example 2.

When it comes to level 02 type, thirteen new sub-prerequisites or sub-credits for existing credits and prerequisites were developed under the existing eight categories through integrating the guidelines. Those thirteen new sub-prerequisites or sub-credits are as follows;

a) A new sub-prerequisite was introduced to the ‘Prerequisite 2 - Commissioning Clauses’ of first category, ‘Management’ as, “Structural Health Monitoring and Maintenance of the Building”.
b) A new sub-prerequisite was introduced to the ‘Prerequisite 1 – Erosion and Sediment Control’ of second category, ‘Sustainable Sites’ as, “Implement sediment and erosion control plan which also will reduce the risk of occurrence and damage due to natural hazards”.
c) A new sub-credit was introduced to the ‘Credit 1 – Site Selection’ of second category, ‘Sustainable Sites’ as, “Inappropriate site avoidance to reduce the vulnerability from natural hazards”.
d) Two new sub-credits were introduced to the ‘Credit 2 – Site Assessment and Development’ of second category, ‘Sustainable Sites’ as, “Architectural & design aspect which can withstand natural hazards specially floods, heavy winds or storms and landslides” and “All buildings situated in hazard prone areas should use relevant hazard mitigation & preparedness measures as specified in NBRO guideline”.
e) Two new sub-credits were introduced to the ‘Credit 4 – Brownfield Redevelopment and Allowance for Connectivity of Green Lands’ of second category, ‘Sustainable Sites’ as, “Check the resilience of the brownfield land for potential hazards before the redevelopment” and “Increase the resilience of the brownfield land in the brownfield redevelopment stage”.
f) A new sub-credit was introduced to the ‘Credit 5 – Alternative Transportation’ of second category, ‘Sustainable Sites’ as, “Transportation Needs during an Emergency”.

g) A new exemplary performance mark was introduced to the 'Credit 2 – Use of water saving performances' of third category, 'Water Efficiency' to have water efficiency during emergency power shuts.
h) A new sub-credit was introduced to the 'Credit 2 – Renewable Energy' of forth category, 'Energy and Atmosphere' as, "Renewable energy usage during emergencies".
i) A new sub-credit was introduced to the 'Credit 6 – Controllability of Systems' of sixth category, 'Indoor Environmental Quality' as, "Emergency Lighting".
j) A new sub-credit and a new exemplary performance mark were introduced to the 'Credit 1 – Social Wellbeing, Public Health & Safety' of eighth category, 'Social and Cultural Awareness' as, "Enhancing public safety during emergencies" and regarding installation of flood and landslide warning systems.

For better explanation about the development and integration of guidelines under level 02 as a new sub-prerequisite or a sub-credit under the existing credits and prerequisites, 'b)' will be taken as the Example 3. Newly added content is underlined in red color for identification purposes.

When it comes to level 03 type, ten new minor improvements or amendments were done to sub-prerequisites & sub-credits under the existing eight categories through integrating the guidelines. Those ten new minor amendments are as follows;

a) Green accredited professional with expertise knowledge on green building & sustainability concepts together with Disaster Risk Reduction (DRR) & disaster resilience aspects – MN Prerequisite 1: Green Building Accredited Professional
b) A separate section about emergency handling mechanisms during a hazard incorporated in to the building user guide – MN Prerequisite 3: Building User's Guide
c) Flood controlling through storm water controlling using watershed management technique – SS Credit 2.7: Storm Water Design, Quantity Control
d) Exemplary performance mark for reduction of portable water usage by 150% through rainwater harvesting – WE Credit 3.5: Innovative Wastewater Technologies
e) Develop and utilize a commissioning plan for Lightening Protection – EA Prerequisite 1: Fundamental Building Systems Commissioning
f) Design HVAC systems based on future climate changes and temperature variances - EA Prerequisite 3: CFC Reduction in HVAC&R Equipment and EQ Credit 6.7 – Thermal Comfort, Design

g) Installation of reliable backup & emergency power sources and communication systems and conducting relevant structural health monitoring checks - EA Credit 4.3: Additional Commissioning
h) Safe hazardous waste collection in flood prone areas – MR Credit 5.2.3 Hazardous Waste Management
i) Safe hazardous material storage in flood prone areas – EQ Credit 6.5 – Indoor Chemical & Pollutant Source Control

For better explanation about the development and integration of guidelines under level 03 as a new minor improvement or an amendment done to sub-prerequisites & sub-credits, ‘f)’ will be taken as the Example 1. Newly added content is underlined in red color for identification purposes.

Example 01: Level 03 - Guidelines are incorporated as a new minor improvement or an amendment done to sub-prerequisites & sub-credits

EQ - Credit 6.7: Thermal Comfort, Design

1 Point + 1 Point

Intent

Provide a comfortable thermal environment that supports the productivity and well-being of building occupants while considering future climate trends.

Requirements

Design HVAC systems and the building envelope of ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy. Demonstrate design compliance in accordance with the Section 6.1.1 Documentation.

Design HVAC systems based on future climate changes and temperature variances.

Potential Technologies & Strategies

Establish comfort criteria per ASHRAE Standard 55-2010 that support the desired quality and occupant satisfaction with building performance. Design building envelope and systems with the capability to deliver performance to the comfort criteria under expected environmental and use conditions. Evaluate air temperature, radiant temperature, air speed, and relative humidity in an integrated fashion and coordinate these criteria with EQ Prerequisite 1, EQ Credit 1, and EQ Credit 2.

Example 02: Level 01 - Guidelines are incorporated as a new subcategory

MN-P4: Emergency Preparedness Information and Instructions Manual

Required

Intent

Develop an emergency preparedness information and instructions manual for apartment residents, homeowners, commercial and other buildings, including model emergency operating procedures and a building contact directory.

Requirements

Emergency Preparedness Information and Instructions Manual should include the following sections,

1. Introduction to the manual
2. Applicable Vulnerable hazards and scenarios
3. Critical Operational Functions, Systems, and Supplies
4. Roles and Responsibilities during a hazard or an emergency
5. Coordinating/Integrating during a hazard or an emergency
6. Evacuation plan (routes, Shelters and stakeholder involvement, etc) including evacuation of disable and people with special health needs during an emergency
7. Building contact & safety directory including all emergency contacts
8. Model emergency operating procedures
9. Training and Education
10. Recourses and references

Potential Technologies & Strategies

- In the introduction section include about how to use the manual and operational procedures while including the operational procedures properly using diagrams and all in the model emergency operating procedures.
- Prepare the manual depending on the hazard vulnerabilities that the building is vulnerable into and possible emergencies that may get to face.

Example 03: Level 02 - Guidelines are incorporated as a new sub-prerequisite or a sub-credit

SS - P1: Erosion and Sedimentation Control

Required

Intent

Control / reduce soil erosion ~~and~~ to minimize negative impacts of waterway sedimentation and airborne dust generation and thereby reduce the risk of occurrence and damage due to natural hazards.

Requirements

2.1.1

Implement sediment and erosion control plan that conforms to the best engineering practices specified by The Construction Industry Development Authority (CIDA) Protection of Landscape during Construction. The plan shall meet the following objectives:

- Prevent loss of soil during construction by storm water run-off and/ or wind erosion, including protecting topsoil by stock-piling for reuse
- Prevent sedimentation of storm sewer or receiving streams and/ or air pollution with dust and particulate matter which will indirectly control flooding due to reduction in sedimentation of water ways.

2.1.2

Implement sediment and erosion control plan which also will reduce the risk of occurrence and damage due to natural hazards;

- Plant trees for erosion control which have a root system effective at holding back soil as a special strategy for landslide prone areas and trees act as a barrier against heavy winds.
- Carry out terracing and contour ploughing, vegetation cover management and afforestation for watershed management where as it controls formation of floodwater which includes land use and soil conservation to minimize surface runoff, erosion and sediment transport.

Potential Technologies & Strategies

- Create an erosion and sedimentation control plan during the design phase of the project. Consider employing strategies such as temporary and permanent seeding, mulching, earth dikes, silt fencing, sediment traps, ~~and~~ sediment basins, tree plantation and introducing a vegetation cover.

3.2 Evaluation of the Incorporated Guidelines

After the development and incorporation of guidelines into the existing 8 categories of the Building tool of the GREENSL® Rating System, evaluation of those incorporated guidelines was carried out using an expert committee meeting. The expected inputs and comments from the expert committee evaluation are as follows,

- To edit the content of the guidelines
- To change the categories of the guidelines
- To add new DRR topics and guidelines
- To change the criteria of the guidelines
- To remove incompatible and unsuitable guidelines for the building tool

The expert committee was comprised of specialists or professionals from different disciplinarians and expertise areas as listed below;

- Green Building and Built Environment Professionals
- Green Accredited Professionals
- Disaster Management Experts
- Civil Engineers
- Electrical and Mechanical Engineers
- Architects

Expert committee was comprised of eleven specialists/professionals from above disciplines as shown in Table 8.

Table 8: Expert Committee for Evaluation of Incorporated Guidelines

Expert	Specialized Areas or Designation	Country
Expert A	Senior Professor and a Charted Engineer in Structural Engineering, Chairman of GBCSL	Sri Lanka
Expert B	Green Accredited Professional	Sri Lanka
Expert C	Project Manager of GBCSL, Green Accredited Professional	Sri Lanka
Expert D	Disaster Management Professor at University of Huddersfield, UK	United Kingdom
Expert E	Disaster Management Professor (Policy Specialist) at University of Huddersfield, UK	United Kingdom
Expert F	Green Accredited Professional and a Charted Architect	Sri Lanka
Expert G	Structural Engineering & Sustainable Built Environment Professor at University of Melbourne, Australia	Australia
Expert H	Director of Disaster Management Centre (DMC) , Sri Lanka	Sri Lanka

Expert I	A Planner at National Building Research Organization (NBRO), Sri Lanka	Sri Lanka
Expert J	Electrical Engineer and an Energy Specialist	Sri Lanka
Expert K	Director of GBCSL and an Economist	Sri Lanka

8 expert committee meetings were conducted with the participation of above specialists on 23/03/2020 from 5.00pm to 6.00pm, 27/03/2020 from 4.30pm to 6.00pm, 31/03/2020 from 5.00pm to 6.00pm, 03/04/2020 from 4.00pm to 5.00pm, 06/04/2020 from 4.30pm to 5.30pm, 10/04/2020 from 6.00pm to 7.30pm, 18/04/2020 form 4.00pm to 5.00pm and 21/04/2020 from 4.00pm to 5.00pm via Zoom online platform. Many comments and inputs were suggested by the expert committee throughout the series of meetings for the improvement of the Building tool of the GREENSL® Rating System for Built Environment. Those comments and inputs are listed below;

a) Input DRR measures to reduce the risk caused due to lightening hazards as the rating tool doesn't have any guideline for that.

b) Change few categories which the guidelines were directed and listed based on their relativity and most suitability. Some guidelines were proposed to list under more than one category or credit/prerequisite.

c) Remove some guidelines which are already in the building codes such as prevention of sewage backflow and some structural and construction guidelines, etc. as they are mandatory to follow when constructing the buildings.

d) Including structural health monitoring checks in both commissioning and additional commissioning sub-categories.

e) Change criteria limits and targets under the credits and prerequisites (Ex: 150% of rainwater harvesting storage) which will result in enhancing the DRR and sustainability of the rating tool.

f) Although fire protection & detection mechanisms are considered in building codes as a mandatory criterion to follow in constructing buildings, it was suggested to include it under commissioning clauses as a prerequisite as it was not an important aspect in the present rating tool.

g) Input a guideline to reduce the risks and enhance the resilience due to infections deceases like COVID-19.

h) Better not to mention about slope stabilization slope criteria as they may vary with new research studies, instead mention only the NBRO Guideline link to refer the criteria.

i) Include some difficult achievables as ‘Exemplary Performance’ such as emergency shut off valves at storages and emergency power for pumping stations during blackouts, etc. which may be difficult for the majority of green buildings.

j) It was suggested to remove some criteria from the building tool due to the difficulty in achieving and transfer them to either city tool or transportation infrastructure tool or both based on the applicability.

k) It was commented that although some guidelines are beneficial for the DRR, it will adversely affect the green building concepts. As an example, encouraging to use concrete as a hazard resilient building material will be favorable in resisting hazards but adversely impact on green building concepts due to increase in carbon foot print of the building.

3.3 Awarding of Credit

Initially the credits were awarded with points (starting from 1 point) depending on the importance and weightage of the DRR and disaster resilient guideline towards the greenery and sustainability of the building. Then the credited rating system was evaluated and reviewed using the same expert committee stated under chapter 3.2, Evaluation of the Incorporated Guidelines. After the inputs and comments received from the expert committee, the rating system was re-credited with the suggested amendments and directed for the next round of review process. After couple of rounds of reviews by the expert committee the credited rating system was ready for validation. Building Tool of the GREENSL® Rating system for Built Environment, incorporated with DRR and disaster resilient measures was comprised of extra 20 points, summing the total number of points into 120 points. The score card of the credited, disaster resilient building tool is shown in Table 9. Newly added content and the amendments done are underlined in red color for better and clear identification purposes.

Table 9: The Score Card of the Credited, Disaster Resilient Building Tool of the GREENSL® Rating system for Built Environment

Prerequisite /Credit	**Criteria**	**Points**	**DRR Points**
1.0 MANAGEMENT (MN): 4 Total Points Available			
Prerequisite 1	Green Building Accredited Professional	Required	
Prerequisite 2	Commissioning Clauses	Required	
Prerequisite 3	Building users guide	Required	
Prerequisite 4	Emergency Preparedness and Information Manual		Required
Credit 1.1	Building Tuning [1 Point]		
	Credit 1.1.1 Optimizing occupant comfort and Energy Efficiency	1 Point	
Credit 1.2	Environmental Management [3 Points]		
	Credit 1.2.1 Involvement of Ecologist	1 Point	
	Credit 1.2.2 Environmental Management Plan	1 Point	
	Credit 1.2.3 Environment Management System (Complying with ISO 14001)	1 Point	
2.0 SUSTAINABLE SITES (SS): 25 Total Points Available + Extra 10 Points for DRR			
Prerequisite 1	Erosion and Sedimentation Control	Required	
Credit 2.1	Site Selection [4 Points + 4 Points]		
	Credit 2.1.1 Inappropriate site avoidance to reduce adverse environmental impacts	4 Points	
	Credit 2.2.2 Inappropriate site avoidance to reduce the vulnerability from natural hazards		2 Points
Credit 2.2	Site Assessment and development [2 Points + 6 Points]		
	Credit 2.2.1 Site Assessment	2 Points	
	Credit 2.2.2 Architectural and design aspects which can withstand natural hazards		2 Points
	Credit 2.2.3 All buildings situated in hazard prone areas should use		2 Points

	relevant hazard mitigation and preparedness measures		
Credit 2.3	Development Density and Community Connectivity	2 Points	
Credit 2.4	Brownfield Redevelopment and allowance for connectivity of Green Lands [1 Point + 2 Points]		
	Credit 2.4.1 Develop on a site classified as a brownfield and provide remediation as required	1 Point	
	Credit 2.4.2 Check the resilience of brownfield lands for potential hazards before redevelopment		1 Point
	Credit 2.4.3 Increase the resilience of the brownfield land in the brownfield redevelopment stage		1 Point
Credit 2.5	Alternative Transportation [3 Points + 1 Point]		
	Credit 2.5.1 Public Transportation Access	1 Point	
	Credit 2.5.2 Parking Capacity	1 Point	
	Credit 2.5.3 Encourage use of green modes of transport	1 Point	
	Credit 2.5.4 Transportation needs during an emergency		1 Point
Credit 2.6	Reduced Site Disturbance [6 Points]		
	Credit 2.6.1 Protect or Restore Habitat	2 Points	
	Credit 2.6.2 Vertical greening	2 Points	
	Credit 2.6.3 Development footprint	2 Points	
Credit 2.7	Storm Water Design, Quantity Control	2 Points	1 Point
Credit 2.8	Storm Water Design, Quality Control	2 Points	
Credit 2.9	Heat Island Effect, Non – Roof	1 Point	
Credit 2.10	Heat Island Effect, Roof	1 Point	
Credit 2.11	Light Pollution Reduction	1 Point	
3.0 WATER EFFICIENCY (WE): 14 Total Points Available			
Prerequisite 1	Eliminate potable water consumption for irrigation and landscaping	Required	
Credit 3.1	Use of alternative water sources	1 Point	
Credit 3.2	Use of water-saving performances	1 Point	

	Exemplary Performance Marks (1)		√
Credit 3.3	Indoor water use reduction	1 – 4 Points	
Credit 3.4	Water Efficiency in air conditioning system	1 Point	
Credit 3.5	Innovative Wastewater Technologies [1-5 Points]		
	Credit 3.5.1: Reduce Potable Water Use	1 Point	
	Credit 3.5.2: Reduce Potable Water Use or Treat Wastewater	1 Point	
	Credit 3.5.3: Harvested rainwater	2 Points	
	Exemplary Performance Marks (2)		√
	Credit 3.5.4: Aquifer Recharge	1 Point	
Credit 3.6	Innovative Water Transmission	1 Point	
Credit 3.7	Ground Water Recharge, if Ground Water Sources are Tapped	1 Point	
4.0 ENERGY AND ATMOSPHERE (EA): 22 Total Points Available + Extra 2 Points for DRR			
Prerequisite 1	Fundamental Building Systems Commissioning	Required	
Prerequisite 2	Minimum Energy Performance	Required	
Prerequisite 3	CFC Reduction in HVAC & R Equipment	Required	
Credit 4.1	Optimize Energy Performance	1 – 10 Points	
Credit 4.2	Renewable Energy [1 – 6 Points + 1 Point]		
	Credit 4.2.1 Renewable energy usage	1 – 6 Points	
	Credit 4.2.2 Renewable energy usage during emergencies		1 Point
Credit 4.3	Additional Commissioning	1 Point	1 Point
Credit 4.4	Ozone Depletion	1 Point	
Credit 4.5	Measurement & Verifications	1 – 2 Points	
Credit 4.6	Green Power	1 Point	
Credit 4.7	Certified Energy Auditor	1 Point	
5.0 MATERIALS, RESOURCES & WASTE MANAGEMENT: 14 Total Points Available + Extra 1 Point for DRR			
5.1 MATERIALS AND RESOURCES			
Prerequisite 1	Storage and collection of recyclables	Required	
Credit 5.1.1	Building Reuse [1-2 Points]		
	Credit 5.1.1.1: Maintaining 75% of Existing Building Structure and Shell	1 Point	

	Credit 5.1.1.2: Maintaining 75% of Existing Building Structure and Shell and 25% of Non-Shell Areas	2 Points	
Credit 5.1.2	Resource reuse [1-2 Points]		
	Credit 5.1.2.1: for at least 10% of the Building	1 Point	
	Credit 5.1.2.2: for at least 20% of the Building	2 Points	
Credit 5.1.3	Recycled Content	1 Point	
Credit 5.1.4	Local/ Regional Materials	1 Point	
Credit 5.1.5	Rapidly Renewable materials	1 Point	
Credit 5.1.6	Certified wood and other building materials	1 Point	
Credit 5.1.7	Global Warming Potential of buildings	1 Point	
Credit 5.1.8	Materials Produced with Waste materials	1 Point	
Credit 5.1.8	Hazard Resilient Building Materials		1 Point
5.2 WASTE MANAGEMENT			
Credit 5.2.1	Construction Waste Management [1-2 Points]		
	Credit 5.2.1.1: for 50% recycling	1 Point	
	Credit 5.2.1.2: for 75% Recycling	2 Points	
Credit 5.2.2	Operational solid waste management	1 Point	
Credit 5.2.3	Hazardous Waste Management	1 Point	
6.0 INDOOR ENVIRONMENTAL QUALITY (EQ): 13 Total Points Available + Extra 3 Points for DRR			
Prerequisite 1	Minimum IAQ Performance	Required	
Prerequisite 2	Smoke (ETS) Control	Required	
Prerequisite 3	Minimum Acoustic Performance	Required	
Credit 6.1	Outdoor air delivering Monitoring	1 Point	
Credit 6.2	Increased Ventilation	1 Point	
Credit 6.3	Construction IAQ Management Plan	1 Point	
Credit 6.4	Low- Emitting Materials [1-3 Points]		
	Credit 6.4.1 Paints and Coatings	1 Point	
	Credit 6.4.2 Carpet Systems	1 Point	
	Credit 6.4.3 Composite Timber and Agrifibre Products	1 Point	
Credit 6.5	Indoor Chemical & Pollutant Source Control	1 Point	1 Point

Credit 6.6	Controllability of systems [1-2 Points + 1 Point]		
	Credit 6.6.1 Lighting controls	1 Point	
	Credit 6.6.2 Comfort controls	1 Point	
	Credit 6.6.3 Emergency Lighting		1 Point
Credit 6.7	Thermal comfort, design	1 Point	1 Point
Credit 6.8	Thermal comfort, verification	1 Point	
Credit 6.9	Daylight & Views [2 Points]		
	Credit 6.9.1 Daylight	1 Point	
	Credit 6.9.2 Views	1 Point	
7.0 INNOVATION & DESIGN PROCESS (ID): 4 Total Points Available + Extra 2 Points for DRR			
Credit 7.1	Innovation in Design [1-4 Points + 1-2 Points]		
	Credit 7.1.1 Innovation in design	1 – 2 Points	
	Credit 7.1.2 Exemplary Performance	1 – 2 Points	1 – 2 Points
8.0 SOCIAL & CULTURAL AWARENESS (SC): 4 Total Points Available + Extra 2 Points for DRR			
Prerequisite 1	Archaeological sites & Heritage buildings	Required	
Credit 8.1	Social Wellbeing, Public Health & Safety [1–2 Points + 1-2 Points]		
	Credit 8.1.1 Enhancing social wellbeing and public health	1 – 2 Points	
	Credit 8.1.2 Enchasing public safety during emergencies		1 – 2 Points
	Exemplary Performance Marks (3)		√
Credit 8.2	Cultural Identity	1 – 2 Points	
Total Number of Points		100	20

3.4 Applicability Evaluation and Validation

Applicability evaluation and validation were carried out through a series of surveys carried out using green certified buildings by GBCSL. Eleven certified buildings were chosen depending on their geographical location based on hazards and rating levels. Following are the breakdown of buildings chosen for the survey;

- 3 buildings located in flood prone areas
- 3 buildings located in landslide prone areas
- 3 buildings located in high wind areas
- 3 buildings located in less or zero hazard prone areas

Also, the list of buildings chosen with their details are tabulated in Table 10;

Table 10: List of Buildings and Their Details Which are Chosen for the Validation Survey

Project	**Building Type**	**Location**	**Hazard**	**Awarded Green Certification**
Project A	Factory and Stores	Badalgama	Floods	Gold
Project B	Factory	Millewa	Floods	Platinum
Project C	Administrative Building	Badulla	Landslides	Gold
Project D	Supermarket	Kegalle	Landslides	Platinum
Project E	Consumer goods Factory	Pannala	Landslides	Gold
Project F	Cement Factory	Trincomalee	Heavy Winds & Tsunami	Platinum
Project G	Hospital	Batticaloa	Heavy Winds & Tsunami	Gold
Project H	Bank	Kalmunai	Heavy Winds & Tsunami	Platinum
Project I	University Building	Homagama	Vulnerability NS	Gold
Project J	Fuel Station Building	Pepiliyana	Vulnerability NS	Silver
Project K	Hotel	Galgamuwa	Vulnerability NS	Platinum

*NS = Not Significant

Then the certified reports and score cards of those buildings together with the building tool of the GREENSL® Rating system for Built Environment and newly developed disaster resilient building tool were used for the validation surveys. Points were awarded to the buildings using the newly developed disaster resilient building tool based on the current conditions of the buildings while considering their hazard prone conditions as well. Then the new score card and the certification type received based on the number of points earned based on newly developed disaster resilient building tool was compared with the original score card and certification type based on the existing building tool of the GREENSL® Rating system for Built Environment were compared.

4 RESULTS AND ANALYSIS

In this section, four sample validation surveys are shown in Table 11, Table 12, Table 13 and Table 14 based on the above discussed 4 categories (flood prone areas, landslide prone areas, heavy wind prone areas and less or zero hazard prone areas) of the location of the buildings using the and newly developed disaster resilient building tool. Although 20 points are allocated for DRR in this tool, points are allocated based on the applicable hazards for the respective building site. Therefore, number of applicable points may be varied depending on the location and vulnerable hazards.

Table 11: The Score Card for the Project A at Badalgama using the Disaster Resilient Building Tool of the GREENSL® Rating system for Built Environment

Prerequisite /Credit	**Criteria**	**Points Available**		**Points Earned**	
		Green Points	**DRR Points**	**Green Points**	**DRR Points**
1.0 MANAGEMENT (MN): 4 Total Points Available					
Prerequisite 1		Required		√	
Prerequisite 2		Required		√	
Prerequisite 3		Required		√	
Prerequisite 4			Required		√
Credit 1.1	Building Tuning [1 Point]				
	Credit 1.1.1	1 Point		1 Point	
Credit 1.2	Environmental Management [3 Points]				
	Credit 1.2.1	1 Point		0	
	Credit 1.2.2	1 Point		1 Point	
	Credit 1.2.3	1 Point		1 Point	
2.0 SUSTAINABLE SITES (SS): 25 Total Points Available + Extra 10 Points for DRR					
Prerequisite 1		Required		√	
Credit 2.1	Site Selection [4 Points + 4 Points]				
	Credit 2.1.1	4 Points		4 Points	
	Credit 2.2.2		2 Points		0
Credit 2.2	Site Assessment and development [2 Points + 6 Points]				
	Credit 2.2.1	2 Points		0	
	Credit 2.2.2		2 Points		0
	Credit 2.2.3		2 Points		0
Credit 2.3		2 Points		2 Points	
Credit 2.4	Brownfield Redevelopment and allowance for connectivity of Green Lands [1 Point + 2 Points]				
	Credit 2.4.1	1 Point		0	

	Credit 2.4.2		1 Point		0
	Credit 2.4.3		1 Point		0
Credit 2.5	Alternative Transportation [3 Points + 1 Point]				
	Credit 2.5.1	1 Point		1 Point	
	Credit 2.5.2	1 Point		1 Point	
	Credit 2.5.3	1 Point		1 Point	
	Credit 2.5.4		1 Point		0
Credit 2.6	Reduced Site Disturbance [6 Points]				
	Credit 2.6.1	2 Points		2 Points	
	Credit 2.6.2	2 Points		0	
	Credit 2.6.3	2 Points		2 Points	
Credit 2.7		2 Points	1 Point	2 Points	1 Point
Credit 2.8		2 Points		2 Points	
Credit 2.9		1 Point		1 Point	
Credit 2.10		1 Point		1 Point	
Credit 2.11		1 Point		1 Point	
3.0 WATER EFFICIENCY (WE): 14 Total Points Available					
Prerequisite 1		Required		√	
Credit 3.1		1 Point		1 Point	
Credit 3.2		1 Point		0	
	ExP (1)		√		X
Credit 3.3		1 – 4 Points		2 Points	
Credit 3.4		1 Point		1 Point	
Credit 3.5	Innovative Wastewater Technologies [1-5 Points]				
	Credit 3.5.1:	1 Point		1 Point	
	Credit 3.5.2:	1 Point		1 Point	
	Credit 3.5.3:	2 Points		2 Points	
	ExP (2)		√		Partial √
	Credit 3.5.4:	1 Point		1 Point	
Credit 3.6		1 Point		1 Point	
Credit 3.7		1 Point		1 Point	
4.0 ENERGY AND ATMOSPHERE (EA): 22 Total Points Available + Extra 2 Points for DRR					
Prerequisite 1		Required		√	
Prerequisite 2		Required		√	
Prerequisite 3		Required		√	
Credit 4.1		1 – 10 Points		9 Points	
Credit 4.2	Renewable Energy [1 – 6 Points + 1 Point]				
	Credit 4.2.1	1 – 6 Points		5 Points	
	Credit 4.2.2		1 Point		0

Credit 4.3		1 Point	1 Point	1 Point	0
Credit 4.4		1 Point		1 Point	
Credit 4.5		1 – 2 Points		1 Point	
Credit 4.6		1 Point		0	
Credit 4.7		1 Point		0	
5.0 MATERIALS, RESOURCES & WASTE MANAGEMENT: 14 Total Points Available + Extra 1 Point for DRR					
5.1 MATERIALS AND RESOURCES					
Prerequisite 1		Required		√	
Credit 5.1.1	Building Reuse [1-2 Points]				
	Credit 5.1.1.1:	1 Point		0	
	Credit 5.1.1.2:	2 Points		0	
Credit 5.1.2	Resource reuse [1-2 Points]				
	Credit 5.1.2.1:	1 Point		0	
	Credit 5.1.2.2:	2 Points		0	
Credit 5.1.3		1 Point		1 Point	
Credit 5.1.4		1 Point		0	
Credit 5.1.5		1 Point		0	
Credit 5.1.6		1 Point		0	
Credit 5.1.7		1 Point		0	
Credit 5.1.8		1 Point		0	
Credit 5.1.9			1 Point		0
5.2 WASTE MANAGEMENT					
Credit 5.2.1	Construction Waste Management [1-2 Points]				
	Credit 5.2.1.1:	1 Point			
	Credit 5.2.1.2:	2 Points		2 Points	
Credit 5.2.2		1 Point		1 Point	
Credit 5.2.3		1 Point		0	
6.0 INDOOR ENVIRONMENTAL QUALITY (EQ): 13 Total Points Available + Extra 3 Points for DRR					
Prerequisite 1		Required		√	
Prerequisite 2		Required		√	
Prerequisite 3		Required		√	
Credit 6.1		1 Point		0	
Credit 6.2		1 Point		0	
Credit 6.3		1 Point		1 Point	
Credit 6.4	Low- Emitting Materials [1-3 Points]				
	Credit 6.4.1	1 Point		1 Point	
	Credit 6.4.2	1 Point		1 Point	
	Credit 6.4.3	1 Point		1 Point	

Credit 6.5		1 Point	1 Point	1 Point	0
Credit 6.6	Controllability of systems [1-2 Points + 1 Point]				
	Credit 6.6.1	1 Point		1 Point	
	Credit 6.6.2	1 Point		1 Point	
	Credit 6.6.3		1 Point		1 Point
Credit 6.7		1 Point	1 Point	1 Point	0
Credit 6.8		1 Point		1 Point	
Credit 6.9	Daylight & Views [2 Points]				
	Credit 6.9.1	1 Point		1 Point	
	Credit 6.9.2	1 Point		1 Point	
7.0 INNOVATION & DESIGN PROCESS (ID): 4 Total Points Available + Extra 2 Points for DRR					
Credit 7.1	Innovation in Design [1-4 Points + 1-2 Points]				
	Credit 7.1.1	1 – 2 Points		0	
	Credit 7.1.2	1 – 2 Points	1 – 2 Points	1 Point	0
8.0 SOCIAL & CULTURAL AWARENESS (SC): 4 Total Points Available + Extra 2 Points for DRR					
Prerequisite 1		Required		√	
Credit 8.1	Social Wellbeing, Public Health & Safety [1–2 Points + 1-2 Points]				
	Credit 8.1.1	1 – 2 Points		1 Point	
	Credit 8.1.2		1 – 2 Points		1 Point
	ExP (3)		√		X
Credit 8.2		1 – 2 Points		0	
Total Number of Points		100	20	68%	3/20

Before applying the newly developed disaster resilient building tool of the GREENSL® Rating system for Built Environment the project has score 68 marks out of 100 by owning a gold rated green certification. But After applying the newly developed disaster resilient building tool, total points have summed up to 71 out of 120 points (all 20 points allocated for DRR have been considered). As a percentage the score is 59%, which will degrade the green certification to a silver.

Table 12: The Score Card for the Project C at Badulla using the Disaster Resilient Building Tool of the GREENSL® Rating system for Built Environment

Prerequisite /Credit	**Criteria**	**Points Available**		**Points Earned**	
		Green Points	**DRR Points**	**Green Points**	**DRR Points**
1.0 MANAGEMENT (MN): 4 Total Points Available					
Prerequisite 1		Required		√	
Prerequisite 2		Required		√	
Prerequisite 3		Required		√	
Prerequisite 4			Required		√
Credit 1.1	Building Tuning [1 Point]				
	Credit 1.1.1	1 Point		1 Point	
Credit 1.2	Environmental Management [3 Points]				
	Credit 1.2.1	1 Point		1 Point	
	Credit 1.2.2	1 Point		1 Point	
	Credit 1.2.3	1 Point		1 Point	
2.0 SUSTAINABLE SITES (SS): 25 Total Points Available + Extra 10 Points for DRR					
Prerequisite 1		Required		√	
Credit 2.1	Site Selection [4 Points + 4 Points]				
	Credit 2.1.1	4 Points		4 Points	
	Credit 2.2.2		2 Points		2 Points
Credit 2.2	Site Assessment and development [2 Points + 6 Points]				
	Credit 2.2.1	2 Points		2 Points	
	Credit 2.2.2		2 Points		0
	Credit 2.2.3		2 Points		0
Credit 2.3		2 Points		2 Points	
Credit 2.4	Brownfield Redevelopment and allowance for connectivity of Green Lands [1 Point + 2 Points]				
	Credit 2.4.1	1 Point		0	
	Credit 2.4.2		1 Point		0
	Credit 2.4.3		1 Point		0
Credit 2.5	Alternative Transportation [3 Points + 1 Point]				
	Credit 2.5.1	1 Point		1 Point	
	Credit 2.5.2	1 Point		1 Point	
	Credit 2.5.3	1 Point		1 Point	
	Credit 2.5.4		1 Point		0
Credit 2.6	Reduced Site Disturbance [6 Points]				
	Credit 2.6.1	2 Points		2 Points	

	Credit 2.6.2	2 Points		0	
	Credit 2.6.3	2 Points		2 Points	
Credit 2.7		2 Points	1 Point	1 Point	0
Credit 2.8		2 Points		0	
Credit 2.9		1 Point		1 Point	
Credit 2.10		1 Point		0	
Credit 2.11		1 Point		1 Point	
3.0 WATER EFFICIENCY (WE): 14 Total Points Available					
Prerequisite 1		Required		√	
Credit 3.1		1 Point		1 Point	
Credit 3.2		1 Point		1 Point	
	ExP (1)		√		X
Credit 3.3		1 – 4 Points		4 Points	
Credit 3.4		1 Point		1 Point	
Credit 3.5	Innovative Wastewater Technologies [1-5 Points]				
	Credit 3.5.1:	1 Point		0	
	Credit 3.5.2:	1 Point		0	
	Credit 3.5.3:	2 Points		2 Points	
	ExP (2)		√		X
	Credit 3.5.4:	1 Point		1 Point	
Credit 3.6		1 Point		0	
Credit 3.7		1 Point		1 Point	
4.0 ENERGY AND ATMOSPHERE (EA): 22 Total Points Available + Extra 2 Points for DRR					
Prerequisite 1		Required		√	
Prerequisite 2		Required		√	
Prerequisite 3		Required		√	
Credit 4.1		1 – 10 Points		10 Points	
Credit 4.2	Renewable Energy [1 – 6 Points + 1 Point]				
	Credit 4.2.1	1 – 6 Points		3 Points	
	Credit 4.2.2		1 Point		1 Point
Credit 4.3		1 Point	1 Point	1 Point	0
Credit 4.4		1 Point		1 Point	
Credit 4.5		1 – 2 Points		0	
Credit 4.6		1 Point		0	
Credit 4.7		1 Point		1 Point	
5.0 MATERIALS, RESOURCES & WASTE MANAGEMENT: 14 Total Points Available + Extra 1 Point for DRR					
5.1 MATERIALS AND RESOURCES					
Prerequisite 1		Required		√	

Credit 5.1.1	Building Reuse [1-2 Points]				
	Credit 5.1.1.1:	1 Point		0	
	Credit 5.1.1.2:	2 Points		0	
Credit 5.1.2	Resource reuse [1-2 Points]				
	Credit 5.1.2.1:	1 Point		0	
	Credit 5.1.2.2:	2 Points		0	
Credit 5.1.3		1 Point		1 Point	
Credit 5.1.4		1 Point		0	
Credit 5.1.5		1 Point		0	
Credit 5.1.6		1 Point		1 Point	
Credit 5.1.7		1 Point		0	
Credit 5.1.8		1 Point		0	
Credit 5.1.9			1 Point		0
5.2 WASTE MANAGEMENT					
Credit 5.2.1	Construction Waste Management [1-2 Points]				
	Credit 5.2.1.1:	1 Point		0	
	Credit 5.2.1.2:	2 Points		0	
Credit 5.2.2		1 Point		1 Point	
Credit 5.2.3		1 Point		1 Point	
6.0 INDOOR ENVIRONMENTAL QUALITY (EQ): 13 Total Points Available + Extra 3 Points for DRR					
Prerequisite 1		Required		√	
Prerequisite 2		Required		√	
Prerequisite 3		Required		√	
Credit 6.1		1 Point		0	
Credit 6.2		1 Point		0	
Credit 6.3		1 Point		1 Point	
Credit 6.4	Low- Emitting Materials [1-3 Points]				
	Credit 6.4.1	1 Point		1 Point	
	Credit 6.4.2	1 Point		1 Point	
	Credit 6.4.3	1 Point		1 Point	
Credit 6.5		1 Point	1 Point	1 Point	N/A
Credit 6.6	Controllability of systems [1-2 Points + 1 Point]				
	Credit 6.6.1	1 Point		1 Point	
	Credit 6.6.2	1 Point		0	
	Credit 6.6.3		1 Point		0
Credit 6.7		1 Point	1 Point	0	0
Credit 6.8		1 Point		1 Point	
Credit 6.9	Daylight & Views [2 Points]				
	Credit 6.9.1	1 Point		1 Point	

	Credit 6.9.2	1 Point		1 Point	
7.0 INNOVATION & DESIGN PROCESS (ID): 4 Total Points Available + Extra 2 Points for DRR					
Credit 7.1	Innovation in Design [1-4 Points + 1-2 Points]				
	Credit 7.1.1	1 – 2 Points		0	
	Credit 7.1.2	1 – 2 Points	1 – 2 Points	1 Point	0
8.0 SOCIAL & CULTURAL AWARENESS (SC): 4 Total Points Available + Extra 2 Points for DRR					
Prerequisite 1		Required		√	
Credit 8.1	Social Wellbeing, Public Health & Safety [1–2 Points + 1-2 Points]				
	Credit 8.1.1	1 – 2 Points		1 Point	
	Credit 8.1.2		1 – 2 Points		0
	ExP (3)		√		X
Credit 8.2		1 – 2 Points			
Total Number of Points		100	20	64	3/19

Before applying the newly developed disaster resilient building tool of the GREENSL® Rating system for Built Environment the project has score 64 marks out of 100 by owning a gold rated green certification. But After applying the newly developed disaster resilient building tool, total points have summed up to 67 out of 119 points (19 points out of 20 points allocated for DRR have been considered). As a percentage the score is 54%, which will degrade the green certification to a silver.

Table 13: The Score Card for the Project F at Trincomalee using the Disaster Resilient Building Tool of the GREENSL® Rating system for Built Environment

Prerequisite /Credit	Criteria	Points Available		Points Earned	
		Green Points	DRR Points	Green Points	DRR Points
1.0 MANAGEMENT (MN): 4 Total Points Available					
Prerequisite 1		Required		√	
Prerequisite 2		Required		√	
Prerequisite 3		Required		√	
Prerequisite 4			Required		√
Credit 1.1	Building Tuning [1 Point]				
	Credit 1.1.1	1 Point		1 Point	
Credit 1.2	Environmental Management [3 Points]				
	Credit 1.2.1	1 Point		0	
	Credit 1.2.2	1 Point		1 Point	
	Credit 1.2.3	1 Point		0	

2.0 SUSTAINABLE SITES (SS): 25 Total Points Available + Extra 10 Points for DRR					
Prerequisite 1		Required		√	
Credit 2.1	Site Selection [4 Points + 4 Points]				
	Credit 2.1.1	4 Points		4 Points	
	Credit 2.2.2		2 Points		2 Points
Credit 2.2	Site Assessment and development [2 Points + 6 Points]				
	Credit 2.2.1	2 Points		0	
	Credit 2.2.2		2 Points		1 Point
	Credit 2.2.3		2 Points		0
Credit 2.3		2 Points		2 Points	
Credit 2.4	Brownfield Redevelopment and allowance for connectivity of Green Lands [1 Point + 2 Points]				
	Credit 2.4.1	1 Point		1 Point	
	Credit 2.4.2		1 Point		1 Point
	Credit 2.4.3		1 Point		1 Point
Credit 2.5	Alternative Transportation [3 Points + 1 Point]				
	Credit 2.5.1	1 Point		1 Point	
	Credit 2.5.2	1 Point		1 Point	
	Credit 2.5.3	1 Point		1 Point	
	Credit 2.5.4		1 Point		0
Credit 2.6	Reduced Site Disturbance [6 Points]				
	Credit 2.6.1	2 Points		2 Points	
	Credit 2.6.2	2 Points		0	
	Credit 2.6.3	2 Points		2 Points	
Credit 2.7		2 Points	1 Point	2 Points	N/A
Credit 2.8		2 Points		2 Points	
Credit 2.9		1 Point		1 Point	
Credit 2.10		1 Point		1 Point	
Credit 2.11		1 Point		1 Point	
3.0 WATER EFFICIENCY (WE): 14 Total Points Available					
Prerequisite 1		Required		√	
Credit 3.1		1 Point		1 Point	
Credit 3.2		1 Point		0	
	ExP (1)		√		X
Credit 3.3		1 – 4 Points		3 Points	
Credit 3.4		1 Point		1 Point	
Credit 3.5	Innovative Wastewater Technologies [1-5 Points]				
	Credit 3.5.1:	1 Point		1 Point	
	Credit 3.5.2:	1 Point		1 Point	

	Credit 3.5.3:	2 Points		2 Points	
	ExP (2)		√		-
	Credit 3.5.4:	1 Point		1 Point	
Credit 3.6		1 Point		1 Point	
Credit 3.7		1 Point		0	
4.0 ENERGY AND ATMOSPHERE (EA): 22 Total Points Available + Extra 2 Points for DRR					
Prerequisite 1		Required		√	
Prerequisite 2		Required		√	
Prerequisite 3		Required		√	
Credit 4.1		1 – 10 Points		10 Points	
Credit 4.2	Renewable Energy [1 – 6 Points + 1 Point]				
	Credit 4.2.1	1 – 6 Points		6 Points	
	Credit 4.2.2		1 Point		0
Credit 4.3		1 Point	1 Point	1 Point	0
Credit 4.4		1 Point		1 Point	
Credit 4.5		1 – 2 Points		1 Point	
Credit 4.6		1 Point		1 Point	
Credit 4.7		1 Point		0	
5.0 MATERIALS, RESOURCES & WASTE MANAGEMENT: 14 Total Points Available + Extra 1 Point for DRR					
5.1 MATERIALS AND RESOURCES					
Prerequisite 1		Required		√	
Credit 5.1.1	Building Reuse [1-2 Points]				
	Credit 5.1.1.1:	1 Point		0	
	Credit 5.1.1.2:	2 Points		0	
Credit 5.1.2	Resource reuse [1-2 Points]				
	Credit 5.1.2.1:	1 Point		0	
	Credit 5.1.2.2:	2 Points		0	
Credit 5.1.3		1 Point		1 Point	
Credit 5.1.4		1 Point		1 Point	
Credit 5.1.5		1 Point		0	
Credit 5.1.6		1 Point		1 Point	
Credit 5.1.7		1 Point		0	
Credit 5.1.8		1 Point		0	
Credit 5.1.8			1 Point		0
5.2 WASTE MANAGEMENT					
Credit 5.2.1	Construction Waste Management [1-2 Points]				
	Credit 5.2.1.1:	1 Point			
	Credit 5.2.1.2:	2 Points		2 Points	

Credit 5.2.2		1 Point		1 Point	
Credit 5.2.3		1 Point		0	
6.0 INDOOR ENVIRONMENTAL QUALITY (EQ): 13 Total Points Available + Extra 3 Points for DRR					
Prerequisite 1		Required		√	
Prerequisite 2		Required		√	
Prerequisite 3		Required		√	
Credit 6.1		1 Point		0	
Credit 6.2		1 Point		0	
Credit 6.3		1 Point		1 Point	
Credit 6.4	Low- Emitting Materials [1-3 Points]				
	Credit 6.4.1	1 Point		1 Point	
	Credit 6.4.2	1 Point		1 Point	
	Credit 6.4.3	1 Point		1 Point	
Credit 6.5		1 Point	1 Point	0	N/A
Credit 6.6	Controllability of systems [1-2 Points + 1 Point]				
	Credit 6.6.1	1 Point		1 Point	
	Credit 6.6.2	1 Point		1 Point	
	Credit 6.6.3		1 Point		0
Credit 6.7		1 Point	1 Point	1 Point	0
Credit 6.8		1 Point			
Credit 6.9	Daylight & Views [2 Points]				
	Credit 6.9.1	1 Point		0	
	Credit 6.9.2	1 Point		1 Point	
7.0 INNOVATION & DESIGN PROCESS (ID): 4 Total Points Available + Extra 2 Points for DRR					
Credit 7.1	Innovation in Design [1-4 Points + 1-2 Points]				
	Credit 7.1.1	1 – 2 Points		1 Point	
	Credit 7.1.2	1 – 2 Points	1 – 2 Points	1 Point	0
8.0 SOCIAL & CULTURAL AWARENESS (SC): 4 Total Points Available + Extra 2 Points for DRR					
Prerequisite 1		Required		√	
Credit 8.1	Social Wellbeing, Public Health & Safety [1–2 Points + 1-2 Points]				
	Credit 8.1.1	1 – 2 Points		1 Point	
	Credit 8.1.2		1 – 2 Points		0
	ExP (3)		√		X
Credit 8.2		1 – 2 Points		1 Point	
Total Number of Points		100	20	72	5/18

Before applying the newly developed disaster resilient building tool of the GREENSL® Rating system for Built Environment the project has score 72 marks out of 100 by owning a platinum rated green certification. But After applying the newly developed disaster resilient building tool, total points have summed up to 77 out of 11 points (18 points out of 20 points allocated for DRR have been considered). As a percentage the score is 65%, which will degrade the green certification to a gold.

Table 14: The Score Card for the Project I at Homagama using the Disaster Resilient Building Tool of the GREENSL® Rating system for Built Environment

Prerequisite /Credit	Criteria	Points Available		Points Earned	
		Green Points	DRR Points	Green Points	DRR Points
1.0 MANAGEMENT (MN): 4 Total Points Available					
Prerequisite 1		Required		√	
Prerequisite 2		Required		√	
Prerequisite 3		Required		√	
Prerequisite 4			Required		X
Credit 1.1	Building Tuning [1 Point]				
	Credit 1.1.1	1 Point		1 Point	
Credit 1.2	Environmental Management [3 Points]				
	Credit 1.2.1	1 Point		1 Point	
	Credit 1.2.2	1 Point		1 Point	
	Credit 1.2.3	1 Point		1 Point	
2.0 SUSTAINABLE SITES (SS): 25 Total Points Available + Extra 10 Points for DRR					
Prerequisite 1		Required		√	
Credit 2.1	Site Selection [4 Points + 4 Points]				
	Credit 2.1.1	4 Points		4 Points	
	Credit 2.2.2		2 Points		2 Points
Credit 2.2	Site Assessment and development [2 Points + 6 Points]				
	Credit 2.2.1	2 Points		2 Points	
	Credit 2.2.2		2 Points		N/A
	Credit 2.2.3		2 Points		N/A
Credit 2.3		2 Points		2 Points	
Credit 2.4	Brownfield Redevelopment and allowance for connectivity of Green Lands [1 Point + 2 Points]				
	Credit 2.4.1	1 Point		0	
	Credit 2.4.2		1 Point		N/A
	Credit 2.4.3		1 Point		N/A
Credit 2.5	Alternative Transportation [3 Points + 1 Point]				

	Credit 2.5.1	1 Point		1 Point	
	Credit 2.5.2	1 Point		1 Point	
	Credit 2.5.3	1 Point		0	
	Credit 2.5.4		1 Point		0
Credit 2.6	Reduced Site Disturbance [6 Points]				
	Credit 2.6.1	2 Points		2 Points	
	Credit 2.6.2	2 Points		0	
	Credit 2.6.3	2 Points		2 Points	
Credit 2.7		2 Points	1 Point	2 Points	N/A
Credit 2.8		2 Points		0	
Credit 2.9		1 Point		1 Point	
Credit 2.10		1 Point		1 Point	
Credit 2.11		1 Point		1 Point	
3.0 WATER EFFICIENCY (WE): 14 Total Points Available					
Prerequisite 1		Required		√	
Credit 3.1		1 Point		1 Point	
Credit 3.2		1 Point		0	
	ExP (1)		√		-
Credit 3.3		1 – 4 Points		2 Points	
Credit 3.4		1 Point		1 Point	
Credit 3.5	Innovative Wastewater Technologies [1-5 Points]				
	Credit 3.5.1:	1 Point		0	
	Credit 3.5.2:	1 Point		1 Point	
	Credit 3.5.3:	2 Points		0	
	ExP (2)		√		X
	Credit 3.5.4:	1 Point		1 Point	
Credit 3.6		1 Point		0	
Credit 3.7		1 Point		1 Point	
4.0 ENERGY AND ATMOSPHERE (EA): 22 Total Points Available + Extra 2 Points for DRR					
Prerequisite 1		Required		√	
Prerequisite 2		Required		√	
Prerequisite 3		Required		√	
Credit 4.1		1 – 10 Points		7 Points	
Credit 4.2	Renewable Energy [1 – 6 Points + 1 Point]				
	Credit 4.2.1	1 – 6 Points		1 Point	
	Credit 4.2.2		1 Point		0
Credit 4.3		1 Point	1 Point	1 Point	0
Credit 4.4		1 Point		1 Point	
Credit 4.5		1 – 2 Points		2 Points	

Credit 4.6		1 Point		0	
Credit 4.7		1 Point		1 Point	
5.0 MATERIALS, RESOURCES & WASTE MANAGEMENT: 14 Total Points Available + Extra 1 Point for DRR					
5.1 MATERIALS AND RESOURCES					
Prerequisite 1		Required		√	
Credit 5.1.1	Building Reuse [1-2 Points]				
	Credit 5.1.1.1:	1 Point		0	
	Credit 5.1.1.2:	2 Points		0	
Credit 5.1.2	Resource reuse [1-2 Points]				
	Credit 5.1.2.1:	1 Point		0	
	Credit 5.1.2.2:	2 Points		2 Points	
Credit 5.1.3		1 Point		1 Point	
Credit 5.1.4		1 Point		1 Point	
Credit 5.1.5		1 Point		1 Point	
Credit 5.1.6		1 Point		1 Point	
Credit 5.1.7		1 Point		0	
Credit 5.1.8		1 Point		1 Point	
Credit 5.1.9			1 Point		N/A
5.2 WASTE MANAGEMENT					
Credit 5.2.1	Construction Waste Management [1-2 Points]				
	Credit 5.2.1.1:	1 Point		0	
	Credit 5.2.1.2:	2 Points		2 Points	
Credit 5.2.2		1 Point		1 Point	
Credit 5.2.3		1 Point		0	
6.0 INDOOR ENVIRONMENTAL QUALITY (EQ): 13 Total Points Available + Extra 3 Points for DRR					
Prerequisite 1		Required		√	
Prerequisite 2		Required		√	
Prerequisite 3		Required		√	
Credit 6.1		1 Point		0	
Credit 6.2		1 Point		0	
Credit 6.3		1 Point		1 Point	
Credit 6.4	Low- Emitting Materials [1-3 Points]				
	Credit 6.4.1	1 Point		1 Point	
	Credit 6.4.2	1 Point		1 Point	
	Credit 6.4.3	1 Point		1 Point	
Credit 6.5		1 Point	1 Point	0	N/A
Credit 6.6	Controllability of systems [1-2 Points + 1 Point]				
	Credit 6.6.1	1 Point		1 Point	

	Credit 6.6.2	1 Point		1 Point	
	Credit 6.6.3		1 Point		1 Point
Credit 6.7		1 Point	1 Point	1 Point	0
Credit 6.8		1 Point		1 Point	
Credit 6.9	Daylight & Views [2 Points]				
	Credit 6.9.1	1 Point		1 Point	
	Credit 6.9.2	1 Point		1 Point	
7.0 INNOVATION & DESIGN PROCESS (ID): 4 Total Points Available + Extra 2 Points for DRR					
Credit 7.1	Innovation in Design [1-4 Points + 1-2 Points]				
	Credit 7.1.1	1 – 2 Points		2 Point	
	Credit 7.1.2	1 – 2 Points	1 – 2 Points	1 Point	N/A
8.0 SOCIAL & CULTURAL AWARENESS (SC): 4 Total Points Available + Extra 2 Points for DRR					
Prerequisite 1		Required			
Credit 8.1	Social Wellbeing, Public Health & Safety [1–2 Points + 1-2 Points]				
	Credit 8.1.1	1 – 2 Points		1 Point	
	Credit 8.1.2		1 – 2 Points		0
	ExP (3)		√		-
Credit 8.2		1 – 2 Points		1 Point	
Total Number of Points		100	20	68%	3/9

Before applying the newly developed disaster resilient building tool, the project has score 68 marks out of 100 by owning a gold rated green certification. But After applying the newly developed disaster resilient building tool, total points have summed up to 71 out of 109 points (9 points out of 20 points allocated for DRR have been considered). As a percentage the score is 65%, which will be able to maintain the same green certification, silver, which it obtained before applying the newly developed disaster resilient building tool.

Same as the above 4 examples, rest of the surveys were carried out in selected building sites. The summary of the 11 surveys conducted using the new disaster resilient building tool are analyzed and tabulated in Table 15. Points earned and accordingly the certification obtained using the existing building tool and the new DRR incorporated tool are compered while suggesting the possible and most effective applications of the tools.

Table 15: Summary Table of the Eleven Surveys Conducted using the new disaster resilient building tool of GREENSL® rating system for built environment

Project	**Hazard Vulnerability**	**Existing Building Tool**		**New DRR Incorporated Tool**	
		Points (%)	**Certification**	**Points (%)**	**Certification**
Project A	Floods	68	Gold	59	Silver
Project B	Floods	74	Platinum	66	Gold
Project C	Landslides	64	Gold	56	Silver
Project D	Landslides	71	Platinum	64	Gold
Project E	Landslides	63	Gold	55	Silver
Project F	Heavy Winds & Tsunami	72	Platinum	65	Gold
Project G	Heavy Winds & Tsunami	67	Gold	60	Gold
Project H	Heavy Winds & Tsunami	72	Platinum	66	Gold
Project I	No Sevier Vulnerability	68	Gold	65	Gold
Project J	No Sevier Vulnerability	56	Silver	52	Silver
Project K	No Sevier Vulnerability	71	Platinum	68	Gold

When considering the result of the above table, it is clear that buildings which are situated in flood prone areas have dropped their certification by one level. Points drop has also varied between 8 and 9 points, which seems to create a considerable impact in the certification obtained. Therefore, it’s better to use the building tool incorporated with DRR in certifying the buildings in flood prone areas as well as due to the high frequency and impact created on built environment through the flood hazards in Sri Lanka.

The same observation can be noticed in the buildings situated in landslide prone areas as well. Points have been dropped by 7 to 8 points in all 3 surveys carried out while dropping the certification by one level as well. Therefore, it can be recommended to use the building tool incorporated with DRR in certifying the buildings in land slide areas in this aspect as well. One special aspect which can be noticed here is, all these 3 buildings have incorporated basic design principles applicable to land slide hazard in constructing the buildings.

There’s a slight difference in the scores and certification variation in the buildings which were situated in high wind areas. As most of the buildings considered were situated in the east coastal belt of Sri Lanka, those buildings were also highly vulnerable to Tsunami hazard as well. Although the scope of the research study was out of tsunami risks, during awarding the points, this aspect was taken into consideration. One of the positive aspects noticed in these selected green certified buildings are that, they have considered the wind effect and alkaline effect (due to the locations are near the sea) in architectural and structural design aspects of the building. In these scenarios, points have been dropped by 6 or 7 points due to the moderate consideration of DRR measures against high winds in the selected 3 buildings compared with their existing green certification. Other than one building, the certification level of the rest of the 2 buildings have dropped by one level. Therefore, it also can be recommended to use the building tool incorporated with DRR in certifying the buildings in high wind areas.

When it comes to the buildings which are situated out of hazard vulnerable zones, the droppage of points were only limited to 3 or 4 points. Apart from one building, the rest of the certification levels remained same in the rest of the 2 buildings which the survey was conducted. Even that certification level drop was mainly due to the certification level being marginal to the lower limit of the certification. Therefore, it can be recommended to use the existing building tool in certifying the buildings which are not situated in hazard prone areas. However, incorporating the applicable general DRR measures of the new building tool incorporated with DRR measures is encouraged due to the increasing treads of natural hazards and climate change conditions in the present world and Sri Lanka which will be beneficial in transforming the green buildings into sustainable buildings.

5 FUTURE WORK

5.1 Development and Incorporation of DRR and Disaster Resilient Mechanisms into the City Tool and the Transportation Infrastructure Tool of GREENSL Rating System for Built Environment

In this step, initial 4 steps that was carried out for the building tool were carried out for the City tool and the Transportation Infrastructure Tool of the GREENSL® Rating system. Thereby, DRR and disaster resilient guidelines and mechanisms were developed and incorporated to the existing categories of the respective green rating tools. Same like the building tool, incorporated guidelines can be categories depending on the level of incorporation to the existing tool as follows;

I. Level 01: Guidelines are incorporated as a new category
II. Level 02: Guidelines are incorporated as a new subcategory
III. Level 03: Guidelines are incorporated as a new sub-prerequisite or a sub-credit under the existing credits and prerequisites
IV. Level 04: Guidelines are incorporated as a new minor improvement or an amendment done to sub-prerequisites & sub-credits

Those two disaster resilient rating tools are attached under the Annex 2 and Annex 3 respectively. Newly added content after developments and amendments are noted in red color for identification purposes and clear reference. But these two rating tools are not credited and validated after incorporation of DRR and disaster resilient guidelines due to available recourse constrains and lack of enough applications and certifications using those two rating tools as they are newly introduced rating tools by the GBCSL. Therefore, further researches need to be carried out in transforming the transportation infrastructure tool and the city tool into disaster resilient green rating tools.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Disasters induced by natural hazards are inevitable. Yet taking necessary DRR and disaster resilient measures become a vital necessity with the rapid increment in natural disasters which brings catastrophic damages to the environment, society and the economy and with the continuous boom in global human population. More importantly, these buildings are built to cope for the increasing population and are not properly complying with local building regulations and guidelines and unable to resist the negative impacts created by natural disasters and change of trends such as global warming and change of climate etc. Disaster risk in Sri Lanka has been increasing mainly due to rapid unplanned commercialization and development of cities, infrastructure with poor quality, and the impacts of climate change which has exposed the built environment severely vulnerable to natural hazards. Out of all the hazards, floods, landslides, heavy winds and tsunamis are considered to be the events with highest number of occurrence and also with the highest amount of losses and damages during last 30 years in Sri Lanka.

Although GBCSL has initiated encouraging sustainability and reduced consumption of energy and other resources usage in buildings, it could not specifically identify the need and method of integrating DRR mechanisms into their green rating tools. Even a platinum rated green buildings with lot of sustainable and green related concepts, cannot be sustainable in nature if they are not withstanding against the natural hazards. Therefore, incorporation of DRR and disaster resilient mechanisms into the residential and other buildings, is a transformation towards a sustainable built environment. This research concerns the recognition of structural and non-structural DRR measures for the three disasters floods, landslides and high winds, developing guidelines and then coming up with a new disaster resilient building tool for GREENSL® Rating System for Built Environment under main 8 categories of the existing building tool for GREENSL® Rating System for Built Environment V2.0.

After developing the new disaster resilient building tool for GREENSL® Rating System, eleven surveys were carried out in green certified buildings situated in hazard vulnerable areas for the floods, landslides and high winds as well as less or no hazard prone areas. Those surveys reveled that, it is highly recommended to use new disaster resilient building tool in certifying buildings situated in floods and landslides prone areas, moderately recommended to use the new tool for certification in high wind areas and finally it is acceptable to use the existing building tool for GREENSL® Rating System for Built Environment V2.0 for the buildings situated in less or no hazard prone areas. However, it is advised that the new disaster resilient building tool is in use even for the buildings situated in less or no hazard prone areas by at least incorporating general DRR measures due to the increase of natural hazards and climate change conditions in the modern world and Sri Lanka which will be beneficial in the process of transforming normal buildings to green buildings.

6.2 Recommendations

There are number of important recommendations to be suggested at the end of my research work for future references and continuation of this research. They are as follows;

- Some DRR guidelines incorporated may be difficult to achieve for a developing nation like Sri Lanka, which greening is also not a very popular or a trending concept due to the extra cost incurred in constructing green buildings. Therefore, incorporating DRR measures may incur another extra cost apart from greening.
- Some DRR measures and guidelines contradict with the concepts of greening and sustainability, when it comes to aspects such as zero-carbon emission, life cycle assessment and resources and energy resilience. As an example, use of concrete as a hazard resilient construction material and installation of HVAC systems predicting future climatic changes may consume more energy and recourses as well as emit more carbon to the environment which will contradict with green building concepts. Therefore, it’s better to carry out a proper analysis to identify most sustainable options out of these concepts which contradicts.
- Only eleven surveys were carried out due to lack of green certified buildings situated in hazard prone areas. Therefore, this tool can be further developed as a more practical tool if more surveys can be conducted.
- Although the recommendations to use the new disaster resilient building tool is in high, moderate and no or low levels for different hazards or less or no hazard prone areas, it can vary depends on building type and its usage.
- City tool and the transportation infrastructure tool of GREENSL® Rating System for Built Environment can be further developed, credited and applied which have a higher impact and influence towards the city and infrastructure disaster resilience compared with buildings.

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Annexes

Annex 1: Building Tool of the GREENSL® Rating System for Built Environment Incorporated with DRR and Disaster Resilient Mechanisms

GREENSL® RATING SYSTEM

FOR BUILT ENVIRONMENT

Version 2.0

Green Building Council of Sri Lanka

Committed Leadership in Sustainability

GREENSL® RATING SYSTEM FOR BUILT ENVIRONMENT CHECKLIST

100 Total Points Available + 20 DRR points

Prerequisite /Credit	Criteria	Points	DRR Points
1.0 MANAGEMENT (MN): 4 Total Points Available			
Prerequisite 1	Green Building Accredited Professional	Required	
Prerequisite 2	Commissioning Clauses	Required	
Prerequisite 3	Building users guide	Required	
Prerequisite 4	Emergency Preparedness and Information Manual		Required
Credit 1.1	Building Tuning [1 Point]		
	Credit 1.1.1 Optimizing occupant comfort and Energy Efficiency	1 Point	
Credit 1.2	Environmental Management [3 Points]		
	Credit 1.2.1 Involvement of Ecologist	1 Point	
	Credit 1.2.2 Environmental Management Plan	1 Point	
	Credit 1.2.3 Environment Management System (Complying with ISO 14001)	1 Point	
2.0 SUSTAINABLE SITES (SS): 25 Total Points Available + Extra 10 Points for DRR			
Prerequisite 1	Erosion and Sedimentation Control	Required	
Credit 2.1	Site Selection [4 Points + 4 Points]		
	Credit 2.1.1 Inappropriate site avoidance to reduce adverse environmental impacts	4 Points	
	Credit 2.2.2 Inappropriate site avoidance to reduce the vulnerability from natural hazards		2 Points
Credit 2.2	Site Assessment and development [2 Points + 6 Points]		
	Credit 2.2.1 Site Assessment	2 Points	

	Credit 2.2.2 Architectural and design aspects which can withstand natural hazards		2 Points
	Credit 2.2.3 All buildings situated in hazard prone areas should use relevant hazard mitigation and preparedness measures		2 Points
Credit 2.3	Development Density and Community Connectivity	2 Points	
Credit 2.4	Brownfield Redevelopment and allowance for connectivity of Green Lands [1 Point + 2 Points]		
	Credit 2.4.1 Develop on a site classified as a brownfield and provide remediation as required	1 Point	
	Credit 2.4.2 Check the resilience of brownfield lands for potential hazards before redevelopment		1 Point
	Credit 2.4.3 Increase the resilience of the brownfield land in the brownfield redevelopment stage		1 Point
Credit 2.5	Alternative Transportation [3 Points + 1 Point]		
	Credit 2.5.1 Public Transportation Access	1 Point	
	Credit 2.5.2 Parking Capacity	1 Point	
	Credit 2.5.3 Encourage use of green modes of transport	1 Point	
	Credit 2.5.4 Transportation needs during an emergency		1 Point
Credit 2.6	Reduced Site Disturbance [6 Points]		
	Credit 2.6.1 Protect or Restore Habitat	2 Points	
	Credit 2.6.2 Vertical greening	2 Points	
	Credit 2.6.3 Development footprint	2 Points	
Credit 2.7	Storm Water Design, Quantity Control	2 Points	1 Point
Credit 2.8	Storm Water Design, Quality Control	2 Points	
Credit 2.9	Heat Island Effect, Non – Roof	1 Point	
Credit 2.10	Heat Island Effect, Roof	1 Point	
Credit 2.11	Light Pollution Reduction	1 Point	
3.0 WATER EFFICIENCY (WE): 14 Total Points Available			
Prerequisite 1	Eliminate potable water consumption for irrigation and landscaping	Required	

Credit 3.1	Use of alternative water sources	1 Point	
Credit 3.2	Use of water-saving performances	1 Point	
	Exemplary Performance Marks (1)		√
Credit 3.3	Indoor water use reduction	1 – 4 Points	
Credit 3.4	Water Efficiency in air conditioning system	1 Point	
Credit 3.5	Innovative Wastewater Technologies [1-5 Points]		
	Credit 3.5.1: Reduce Potable Water Use	1 Point	
	Credit 3.5.2: Reduce Potable Water Use or Treat Wastewater	1 Point	
	Credit 3.5.3: Harvested rainwater	2 Points	
	Exemplary Performance Marks (2)		√
	Credit 3.5.4: Aquifer Recharge	1 Point	
Credit 3.6	Innovative Water Transmission	1 Point	
Credit 3.7	Ground Water Recharge, if Ground Water Sources are Tapped	1 Point	
4.0 ENERGY AND ATMOSPHERE (EA): 22 Total Points Available + Extra 2 Points for DRR			
Prerequisite 1	Fundamental Building Systems Commissioning	Required	
Prerequisite 2	Minimum Energy Performance	Required	
Prerequisite 3	CFC Reduction in HVAC & R Equipment	Required	
Credit 4.1	Optimize Energy Performance	1 – 10 Points	
Credit 4.2	Renewable Energy [1 – 6 Points + 1 Point]		
	Credit 4.2.1 Renewable energy usage	1 – 6 Points	
	Credit 4.2.2 Renewable energy usage during emergencies		1 Point
Credit 4.3	Additional Commissioning	1 Point	1 Point
Credit 4.4	Ozone Depletion	1 Point	
Credit 4.5	Measurement & Verifications	1 – 2 Points	
Credit 4.6	Green Power	1 Point	
Credit 4.7	Certified Energy Auditor	1 Point	
5.0 MATERIALS, RESOURCES & WASTE MANAGEMENT: 14 Total Points Available + Extra 1 Point for DRR			
5.1 MATERIALS AND RESOURCES			
Prerequisite 1	Storage and collection of recyclables	Required	
Credit 5.1.1	Building Reuse [1-2 Points]		
	Credit 5.1.1.1: Maintaining 75% of Existing Building Structure and Shell	1 Point	

	Credit 5.1.1.2: Maintaining 75% of Existing Building Structure and Shell and 25% of Non-Shell Areas	2 Points	
Credit 5.1.2	Resource reuse [1-2 Points]		
	Credit 5.1.2.1: for at least 10% of the Building	1 Point	
	Credit 5.1.2.2: for at least 20% of the Building	2 Points	
Credit 5.1.3	Recycled Content	1 Point	
Credit 5.1.4	Local/ Regional Materials	1 Point	
Credit 5.1.5	Rapidly Renewable materials	1 Point	
Credit 5.1.6	Certified wood and other building materials	1 Point	
Credit 5.1.7	Global Warming Potential of buildings	1 Point	
Credit 5.1.8	Materials Produced with Waste materials	1 Point	
Credit 5.1.8	Hazard Resilient Building Materials		1 Point
5.2 WASTE MANAGEMENT			
Credit 5.2.1	Construction Waste Management [1-2 Points]		
	Credit 5.2.1.1: for 50% recycling	1 Point	
	Credit 5.2.1.2: for 75% Recycling	2 Points	
Credit 5.2.2	Operational solid waste management	1 Point	
Credit 5.2.3	Hazardous Waste Management	1 Point	
6.0 INDOOR ENVIRONMENTAL QUALITY (EQ): 13 Total Points Available + Extra 3 Points for DRR			
Prerequisite 1	Minimum IAQ Performance	Required	
Prerequisite 2	Smoke (ETS) Control	Required	
Prerequisite 3	Minimum Acoustic Performance	Required	
Credit 6.1	Outdoor air delivering Monitoring	1 Point	
Credit 6.2	Increased Ventilation	1 Point	
Credit 6.3	Construction IAQ Management Plan	1 Point	
Credit 6.4	Low- Emitting Materials [1-3 Points]		
	Credit 6.4.1 Paints and Coatings	1 Point	
	Credit 6.4.2 Carpet Systems	1 Point	
	Credit 6.4.3 Composite Timber and Agrifibre Products	1 Point	
Credit 6.5	Indoor Chemical & Pollutant Source Control	1 Point	1 Point
Credit 6.6	Controllability of systems [1-2 Points + 1 Point]		
	Credit 6.6.1 Lighting controls	1 Point	

	Credit 6.6.2 Comfort controls	1 Point	
	Credit 6.6.3 Emergency Lighting		1 Point
Credit 6.7	Thermal comfort, design	1 Point	1 Point
Credit 6.8	Thermal comfort, verification	1 Point	
Credit 6.9	Daylight & Views [2 Points]		
	Credit 6.9.1 Daylight	1 Point	
	Credit 6.9.2 Views	1 Point	
7.0 INNOVATION & DESIGN PROCESS (ID): 4 Total Points Available + Extra 2 Points for DRR			
Credit 7.1	Innovation in Design [1-4 Points + 1-2 Points]		
	Credit 7.1.1 Innovation in design	1 – 2 Points	
	Credit 7.1.2 Exemplary Performance	1 – 2 Points	1 – 2 Points
8.0 SOCIAL & CULTURAL AWARENESS (SC): 4 Total Points Available + Extra 2 Points for DRR			
Prerequisite 1	Archaeological sites & Heritage buildings	Required	
Credit 8.1	Social Wellbeing, Public Health & Safety [1–2 Points + 1-2 Points]		
	Credit 8.1.1 Enhancing social wellbeing and public health	1 – 2 Points	
	Credit 8.1.2 Enchasing public safety during emergencies		1 – 2 Points
	Exemplary Performance Marks (3)		√
Credit 8.2	Cultural Identity	1 – 2 Points	
Total Number of Points		100	20

1.0 MANAGEMENT

Prerequisite 1 – Green Building Accredited Professional

Required

Intent

To encourage and recognize the engagement of professionals who can assist the project team with the integration of Green Building aims together with Disaster Risk Reduction (DRR) & disaster resilience mechanisms and processes throughout the design and construction phases.

Requirements

A principal participant in the design team is a Green Building Accredited Professional engaged by the building owner to provide sustainability, Disaster Risk Reduction (DRR) & disaster resilience advices from the schematic design phase up to construction completion.

Ensure that the submission adheres to all provisions of the submission requirements document found on the GBCSL website. To be deemed engaged, in line with the aim of credit, the Green Building accredited professional must contribute substantially.

The Accredited Green Profession should;

- Attend at least 50% of project design meetings and 75% of all building services meeting
- Participate in site visits and site meetings at least once a month
- Prepare site inspection report and forward to project consultant/owner/ GBCSL (Specific format to be introduced)
- Green Rating Proposal Report to be submitted to the GBCSL before construction

Potential Technologies & Strategies

The Green Building accredited professional must remain assigned to the project, from the schematic design stage to construction completion. The assigned Green Building accredited professional should use his the expertise knowledge on green building & sustainability concepts together with Disaster Risk Reduction (DRR) & disaster resilience aspects in the project.

The role of the Green Building accredited professional should be fulfilled by different individuals throughout the project based on their expertise. The evidence above must be submitted for each accredited professional. As the certified assessor will seek to validate that the value to the project was not compromised by the handover, project must also provide a description of the handover procedures for all of the roles of the original Green Building accredited professionals (Qualified Architect, Engineer, Planner and Quantity Surveyor, or any other professionals recognized by the Construction Industry Development Authority (CIDA))

~~Above Green Building accredited professional should have the expertise knowledge on green building & sustainability concepts together with Disaster Risk Reduction (DRR) & disaster resilience aspects as well. In achieving the above criteria, existing green accredited professionals will be trained with a new short course about Disaster Risk Reduction (DRR). For future Green Building accredited professionals, a new module about DRR & disaster resilience will be introduced to the curriculums of the Associate Professional Training (APT) program and advance training program as well to qualify as a green building accredited professional.~~

Prerequisite 2 – Commissioning Clauses

Required

Intent

To encourage and recognize commissioning and handover initiatives to ensure that all building services can operate to optimum design potential.

Requirements

1. **Commissioning and Quality Monitoring**
   Comprehensive pre-commissioning and quality monitoring are contractually required to be performed for all building services (BMS, mechanical, electrical and hydraulic); and the works outlined above to be carried out in exact accordance with CIBSE codes or ASHRAE commissioning guidelines (for services only) and CIBSE commissioning codes for the other services. Also, installation and commissioning of fire protection & detection system according to Fire Regulations by CIDA & by-laws for the fire protection and detection system by CMC. Commissioning plan to be included in Green Rating Proposal Report.

2. **The collaboration of Design Team and Contractor**

   The design team and the Contractor are required to transfer project knowledge to the building owner/manager through all of the following;
   - Documented design intent
   - As-built drawings
   - Operations and Maintenance Manual
   - Commissioning Report
   - Training of building management staff

3. **Health Monitoring and Maintenance of the Building**
   Conduct relevant structural health monitoring checks of the building structures in specific predetermined periodic time intervals (usually annually), depending on the location of the building, under the monitoring and targeting the resilience of the buildings to withstand against the natural and other hazards.

Potential Technologies & Strategies

Where appropriate, information transferred to the building owner may be in the form of a comprehensive Building User's Guide. While this is not required by the referenced standards, the project team is strongly encouraged to consider the implications of commissioning based on indoor air quality, e.g. through establishing an indoor air quality commissioning plan at the design stage with specific provisions for ensuring that this plan is met during and after commissioning.

For Shell and Core projects

Design and Build

If any component of the project is delivered as shell and core or an integrated fit-out, the scope of commissioning must cover the entire traditional scope of fit out provided by the base building (e.g. electrical, mechanical, hydraulic and BMS systems even if some elements will be installed by the tenant). Therefore, it may need to be deferred until the completion of the relevant fit-out works. Commissioning must check against the documented base building design and ensure that the building operates to its design potential.

Prerequisite 3 – Building User's Guide
Required

Intent

Encourage and recognize information management that enables building users to optimize the building's environmental performance.

Requirements

1. A simple and easy-to-use Building User's Guide, which includes information relevant to the building users, occupants and tenants 'representatives, is developed and made available to the building owner. It may contain some useful information that will allow the building users to understand the reason for some procedures included in the Building User's Guide.
2. A separate section/chapter about emergency handling mechanisms during a hazard (including fire hazard) should be incorporated in to the building user guide which covers the emergency response in potential hazards.

Potential Technologies & Strategies

Ensure that the submission is according to all provisions of the submission requirements document found on the GBCSL web site.

The Building Users' Guide must include the following information:

- Energy and Environmental Strategy
- Monitoring and Targeting
- Building Services (Ventilation, Heating and cooling system, Electrical systems, Lighting, Domestic hot water)
- Transport facilities
- Materials and Waste Policies
- Expansion/Re-fit Consideration (Include list if environment recommendations for consideration, highlighting, in particular, the areas covered in the Building Users' Guide).
- Emergency handling mechanisms and procedures during a hazard (including fire hazard)
- References and Further Information

Prerequisite 4 – Emergency Preparedness Information and Instructions Manual

Required

Intent

Develop an emergency preparedness information and instructions manual for apartment residents, homeowners, commercial and other buildings, including model emergency operating procedures and a building contact directory.

Requirements

Emergency Preparedness Information and Instructions Manual should include the following sections,

- Introduction to the manual
- Applicable Vulnerable hazards and scenarios
- Critical Operational Functions, Systems, and Supplies
- Roles and Responsibilities during a hazard or an emergency
- Coordinating/Integrating during a hazard or an emergency
- Evacuation plan (routes, Shelters and stakeholder involvement, etc) including evacuation of disable and people with special health needs during an emergency
- Building contact & safety directory including all emergency contacts
- Model emergency operating procedures
- Training and Education
- Recourses and references

Potential Technologies & Strategies

In the introduction section include about how to use the manual and operational procedures while including the operational procedures properly using diagrams and all in the model emergency operating procedures.

Prepare the manual depending on the hazard vulnerabilities that the building is vulnerable into and possible emergencies that may get to face.

Credit 1.1 – Building Tuning

1 Point

Intent

To encourage and recognize commissioning initiatives that ensure optimum occupant comfort and energy efficient services performance throughout the year.

Requirements

Credit 1.1.1 Optimizing occupant comfort and Energy Efficiency (1 Point)

- After the handover, the building owner implements the tuning of all the building systems
- A relevant member of the design team is involved in the tuning process
- Monthly monitoring is undertaken, and the outcomes are reported to the building owner quarterly
- Full re-commissioning is undertaken 12 months after practical completion
- A building tuning report on the outcomes of the tuning process is provided to the building owner and made available to the design team

Potential Technologies & Strategies

The building tuning process must include;

- Verification that systems are performing to their design potential during all variances in climate and occupancy
- Optimization of time schedules to best match occupant needs and system performance
- Alignment of the operation of the system to the attributes of the built space they serve

Re-commissioning refers to the process of undertaking a review of all systems to the scope of the initial pre-occupancy commissioning. Recommissioning is intended to incorporate any modifications identified as necessary or beneficial during the building tuning period and to improve the performance of building operation. The term does not refer to the resetting of the systems to the initial commissioning settings.

Credit 1.2 – Environmental Management

3 Points

Intent

Encourage and recognize the adoption of a formal environmental management system in line with established guidelines during construction.

Requirements

Credit 1.2.1 Involvement of an Ecologist (Point 1)

Involvement of Ecologists at the design stage and obtain a report of survey ecosystems and assess the diversity, profusions and behavior of the different organisms within them relating to the project and their recommendations.

Credit 1.2.2 Environmental Management Plan (Point 1)

The contractor implements a comprehensive, project-specific environmental management plan (EMP). The contractor should prepare EMP plan before the construction and forward to the GBCSL with the initial proposal. It should include construction dust controlling system, sound controlling system, water pollution controlling in the construction stage and waste management system. *(Specific formats and necessary measuring parameters to be specified by the GBCSL).*

Credit 1.2.3 Environment Management System (Complying with ISO 14001) (Point 1)

The Contractor has valid ISO 14001 Environmental Management System (EMS) accreditation prior to and throughout the project.

Potential Technologies & Strategies

The commitment to the future provision of the EMP does not meet the credit criteria. The EMP must be fully comprehensive and project specific. The GBCSL expect that EMP has been correctly implemented, and internal audit trail tracking compliance will be evident to ensure that there is ongoing compliance during construction.

- www.cibse.org
- www.ashrae.org

2.0 SUSTAINABLE SITES

Prerequisite 1 – Erosion and Sedimentation Control

Required

Intent

Control / reduce soil erosion ~~and~~ to minimize negative impacts of waterway sedimentation and airborne dust generation and thereby reduce the risk of occurrence and damage due to natural hazards

Requirements

1. Implement sediment and erosion control plan that conforms to the best engineering practices specified by The Construction Industry Development Authority (CIDA) Protection of Landscape during Construction. The plan shall meet the following objectives:
    - Prevent loss of soil during construction by storm water run-off and/ or wind erosion, including protecting topsoil by stock-piling for reuse
    - Prevent sedimentation of storm sewer or receiving streams and/ or air pollution with dust and particulate matter which will indirectly control flooding due to reduction in sedimentation of water ways.

2. Implement sediment and erosion control plan which also will reduce the risk of occurrence and damage due to natural hazards
    - Plant trees for erosion control which have a root system effective at holding back soil as a special strategy for landslide prone areas and trees act as a barrier against heavy winds.
    - Carry out terracing and contour ploughing, vegetation cover management and afforestation for watershed management where as it controls formation of floodwater which includes land use and soil conservation to minimize surface runoff, erosion and sediment transport.

Potential Technologies & Strategies

Create an erosion and sedimentation control plan during the design phase of the project. Consider employing strategies such as temporary and permanent seeding, mulching, earth dikes, silt fencing, sediment traps ~~and~~ sediment basins, tree plantation and introducing a vegetation cover.

2.1 - Site Selection

4 Points

Intent

~~Avoid development of inappropriate sites and to reduce the environmental impact from the location of a building on a site~~.

Avoid developments in inappropriate sites to reduce the environmental impact and to reduce the vulnerability from natural hazards for the location of a building on a site.

Requirements

2.1.1 Inappropriate site avoidance to reduce the adverse environmental impacts

Do not develop buildings, roads or parking areas on portions of sites that meet any one of the following criteria:

- Land that is a prime agricultural land.
- Land whose elevation is lower than 1.5m above the elevation of the 50-year flood level.
- Land use along the coastal belt shall comply with the guidelines of the Coast Conservation Department (www.coastal.gov.lk)
- Land which is specifically identified as habitat for any species threatened or endangered species by the Department of Wildlife Conservation – Ministry of Environment.
- The land is within the specified distance of any wetland as defined by Central Environmental Authority, or as defined by local or state rule or law, or the Ramsar Convention, which is the only global environmental treaty. The most stringent condition will apply.
    - http://www.cea.lk
    - http://www.ramsar.org
    - http://dw.iwmi.org/wetland
- Land which is prior to acquisition for the project was public parkland ~~or land identified as landslide-prone areas.~~

2.1.2 Inappropriate site avoidance to reduce the vulnerability from natural hazards

Assess the site condition before design to evaluate sustainable options by completing and documenting site assessment on following;

- Use Hazard Maps and identify the vulnerable hazards and vulnerability level of the site for floods, landslides. Heavy winds and Tsunamis.
- Topography - Contour mapping, unique topographic features, elevation of the land above nearby water bodies can indicate whether the land is vulnerable to floods or inundation, slope of the land to clarify slope stability risk which can

result landslides.

- Hydrology - Proximity to drainage paths, waterways, water bodies, lakes, streams, shorelines, delineated wetlands, marsh-lands, coastline and initial water storage capacity of the site would suggest potential of flood hazard areas.

You can refer the following authorities to get hazard maps;

- Landslide Hazard Zonation Maps – NBRO Guidelines (https://www.nbro.gov.lk)
- Flood Hazard Maps of the River Basins - Irrigation Department (https://nsdi.gov.lk/department-irrigation)
- The Map of Wind Loading Zones Sri Lanka - NBRO Guidelines (https://www.nbro.gov.lk)
- Coastal Line Vulnerability maps for Tsunamis – Coast Conservation Department (www.coastal.gov.lk)

Potential Technologies & Strategies

During the site selection process, give preference to those sites that do not include sensitive site elements and restricted land types. Select a suitable building location and design the building with the minimal footprint to minimize site disruption of those environmentally sensitive areas identified above. Plan to maintain natural environmental conditions.

Refer criteria for the appropriate ground slope levels for constructions which identifies the Ground Slope Suitability by NBRO and other regulatory authorities for the local geographical conditions.

2.2 - Site Assessment and Development

2 Points + 2 Points + 2 Points

Intent

Assess site condition before design to evaluate sustainable options Conserve existing natural areas and restore damaged areas

Requirements

Credit 2.2.1 Site assessment

Complete and document site assessment on following;
Topography- Contour mapping, unique topographic features, slope stability risk.
Hydrology- Flood hazard areas, delineated wetlands, lakes, streams, shorelines, rainwater collection and reuse opportunities, TR-55 initial water storage capacity of the site
Climate- Solar exposure, heat island effect potential, seasonal sun angles, prevailing winds, monthly precipitation and temperature ranges
Vegetation- Primary vegetation types, greenfield area, significant tree mapping, threatened or endangered species, unique habitat, invasive plant species
Soils- Natural Resources Conservation Service soils delineation, Department of Agriculture prime farmland, healthy soils, previous development, disturbed soils
Human use- Views, adjacent transportation infrastructure, adjacent properties, construction materials with existing recycle or reuse potential Human **Health effects-** Proximity of vulnerable populations, adjacent physical activity opportunities, proximity to major sources of air pollution
AND

Preserve and protect from all development and construction activity 40% of the Greenfield area on the site (if such areas exist)

Credit 2.2.2 Architectural & design aspect which can withstand natural hazards specially floods, heavy winds or storms, landslides and tsunamis

- Architectural aspects: Building plan, Orientation and Shape
- Design aspects: Building foundation, superstructure, roof and their combining joints or junctions (Management Commissioning)

(Refer NBRO Guidelines (https://www.nbro.gov.lk) & Guidelines for Buildings at Risk from Natural Disasters by Society of Structural Engineers Sri Lanka)

Credit 2.2.3 All buildings situated in hazard prone areas should use relevant hazard mitigation & preparedness measures as specified in NBRO guideline.

Potential Technologies & Strategies

Team members, typically consisting of the ecologist, landscape architect, land planner, and architect should begin by collecting a wide range of information, such as climate data, topographical maps, nearby building types, and soil survey data.

Engage local experts and specialist

Plan to complete the assessment before conceptual design starts enabling the findings to inform the location and orientation of major program elements.
AND
Restore 30% (including the building footprint) of all portions of the site identified as previously developed, using native or adapted vegetation.
Restore all disturbed or compacted soils that will be re-vegetated within the project's development footprint.
When it comes to architectural aspects of the buildings, building plan and its orientation must be planned for flood prone areas, shorter side of the building shall be oriented to face the direction of the flooding and openings should be placed in line with each other on opposite walls creating a flow path for water. For heavy winds, the wind force on them is minimum where rectangular shaped structures should be planned to have their shorter sides facing the most critical wind direction also should plan to have openings on opposite walls creating a flow path allowing the wind to pass through. For land slide prone areas, it is preferable to plan the orientation of the building in a manner that the Longer side of building to be parallel to contours while maintaining a simple and symmetrical shapes such as square or rectangular shapes.

Also, when it comes to design aspects, building foundation, superstructure, roof and their combining joints or junctions should be designed structurally strong to withstand the pressure from natural hazards specially floods, heavy winds or storms, landslides and tsunamis. (NBRO Guidelines & GUIDELINES FOR BUILDINGS AT RISK FROM NATURAL DISASTERS by Society of Structural Engineers Sri Lanka)

All commercial & residential buildings should use relevant hazard mitigation & preparedness measures as specified in NBRO guideline. As examples for flood & landslides prone areas.

Apply best practices in flood proofing where Constructing the Lower Levels of the building Water Tight with Wet Flood Proofing & Post-Flood Drainage systems (basement infills and flood openings to manage storm water).

- Rising the elevation of building above the Base Flood Elevation (B. F. E.) of the respective construction site and an area with a low probability of flood the space below the living area can be utilized for parking the vehicle, laundry or bathroom etc. The floor elevation shall be raised by increasing the plinth either by building on a higher ground or by creating an elevated ground or Construct the building on silts (The B. F. E. is the water surface level for a flood of 100 years return period.)

- Introduce flood barrier walls as a solution to the threat of flooding at ground levels in storied buildings.

- Require fire protection equipment to be raised in new construction, above the elevation of the 100-year flood level.

- Land use, required earth works, Construction of suitable earth retaining structures & application other slope stabilization techniques, designing of surface & sub-surface drainage networks along the slopes & building construction methods (terraced buildings and elevated structure on columns or raised footings supported on natural ground) can be applied for the constructions carried out in hilly and landslide prone area.

- Plan for at least one small room in the interior of the house which can be structurally strengthened to serve as a safe refuge from cyclone or high wind situations

Credit 2.3 – Development Density and Community Connectivity

2 Points

Intent

Channel development into urban areas with existing infrastructure, protect green fields and preserve habitat and natural recourses.

Requirements

Option1 - Development Density

Construct a building on a previously developed site and in a community with a minimum density of 20,000 square meters per acre net.

OR

Option 2 – Community Connectivity

Construct a building on a previously developed site within 0.8 km of a residential or industrial zone or neighborhood with an average density of 10 units per acre net and with pedestrian access between the building and the services. The Basic services include, but not limited to:
Places of Worship, Hospitals, Pharmacy, Post office, Police Station, Schools, Banks, Super Markets, Parks, Grocery Stores, Day-care Centers, Theatre, Laundry, Library, Restaurants, Community Centers etc.

Potential Technologies & Strategies

During the site selection process, give preference to urban sites or planned industry zones with pedestrian access to a variety of service.

Credit 2.4 – Brownfield Redevelopment and Allowance for Connectivity of Green Lands

1 Point + 2 Points

Intent

Rehabilitate damaged sites where development is complicated by real or perceived environmental contamination, reducing pressure on undeveloped land and to improve a percentage of land as reservations to support biodiversity.

Requirements

2.4.1 Develop on a site classified as a Brownfield and provide remediation as required.

2.4.2 Check the resilience of the brownfield land for potential hazards before the redevelopment

2.4.3 Increase the resilience of the brownfield land in the brownfield redevelopment stage.

Potential Technologies & Strategies

During the site selection process, initially check the resilience of the brownfield land for potential hazards before the redevelopment as stated under credit 2.1.2 and if it is positive to go ahead with give preference to brownfield sites. Identify tax incentives and property cost savings by selecting a Brownfield site. Adopt a site remediation plan and clean up the site using remediation strategies such as pump-and-treat, bioreactors, land farming and in-situ remediation.
Reduce pressure on undeveloped land by rehabilitating damaged sites where development is complicated by environmental contamination. This would typically involve sites such as old rubbish tips, former mining land, old factory sites, etc.
Take necessary required strategies to increase the resilience of the brownfield land in the brownfield redevelopment stage such as;

- Implement a mechanism to treat soil onsite and avoid removal of contaminants to reduce environmental impacts and thereby increase the resilience of the brownfield land
- Introduce green remediation strategies to increase the resilience of the brownfield land such as application of more environmentally friendly, sustainable cleanup practices that lessen the overall environmental impact of the cleanup phase of brownfield revitalization while ensuring it remains protective. (Refer: The guidelines by Sri Lanka Land Development Corporation)

Adopt a sustainable site reclamation/remediation plan; cautious demolishing, preservation of existing building material for reuse and recycling. Clean-up the site using remediation strategies such as pump-and-treat, bioreactors, land farming and in-situ remediation.

Credit 2.5 - Alternative Transportation

3 Points + 1 Point

Intent

Reduce pollution and land development impacts from automobile use.

Requirements

Credit 2.5.1 Public Transportation Access (1 Point)
Locate project within 0.8 km of a railway station or 0.4 km of two or more public bus routes usable by building occupants.

Credit 2.5.2 Parking Capacity (1 Point)
Size parking capacity to meet, but not exceed, minimum local zoning requirements and provide preferred parking for carpools and/or van pools capable of serving 10% of the total provided parking spaces

Credit 2.5.3 Encourage use of green modes of transport (1 Point)
Encourage the use of low emitting, fuel-efficient vehicles, and encourage use of bicycles by building users, at least 25% in quantity of the total vehicles used.

2.5.4 Transportation needs during an emergency (1 Point)
Identify the transportation needs of the people in case of an emergency for the required sites which are vulnerable to hazards only.

Potential Technologies & Strategies

Perform a transportation survey for future building occupants to identify their transportation needs. Locate the building near public transport facilities and design the building with transportation amenities such as,

- Cost and benefits by sharing vehicles with neighbors
- Encourage the use of public transport and use of cycles
- Minimize the parking lot/garage size
- Allocate required transportation facilities, resources and alternative evacuation routes to be used during an emergency to evacuate people especially for the buildings situated in vulnerable sites.
- Consider sharing parking facilities with adjacent buildings and alternatives that will limit the use of single occupied vehicles.
- Provide ―preferred parking spots‖; parking spaces close to the main entrance of the facility.

Credit 2.6 – Reduced Site Disturbance

6 Points

Intent

Conserve existing natural areas and restore damaged areas, to provide habitat and promote biodiversity.

Requirements

Credit 2.6.1 Protect or Restore Habitat (2 Points)

On Greenfield sites, limit site disturbance including earthwork and clearing of vegetation to 15m beyond the building perimeter, 1.5m beyond primary roadway curbs, walkways, and main utility branch trenches, and 8m beyond constructed areas with permeable surfaces (such as pervious paving areas, storm-water detention facilities and playing fields) that require additional staging areas in order to limit compaction in the constructed area.

OR

On previously developed sites, restore a minimum of 50% of the site area (excluding the building footprint) by replacing impervious surfaces with native or adapted vegetation.

Minimize disturbances or restore the site to reduce long-term negative environmental impacts and thereby promote habitat and biodiversity.

Avoid disturbance to the site by retaining natural topography and/or design vegetated spaces on the ground, for at least 15% of the site area.

Credit 2.6.2 Vertical Greening (2 Points)
Provide a green area with native or adapted vegetation throughout an area equivalent to the building footprint within different levels of the building.

Credit 2.6.3 Development Footprint (2 Points)
Reduce the development footprint (defined as the entire building footprint, access roads and parking) to exceed the local zoning‘s open space requirement for the site by 25%. For areas with no local zoning requirements (e.g. some university campuses, military bases), designated open space areas adjacent to the building that is equal to the building footprint.

Potential Technologies & Strategies

Perform a site survey to identify site elements and adopt a master plan to develop the project site. Select a suitable building location and design the building with the minimal footprint to minimize site disruption. Strategies include stacking the building program, tuck under parking and share facilities with neighbors to maximize open space on the site. Establish clearly marked construction boundaries to minimize disturbance of the existing site and restore previously degraded areas to their natural state.

On previously developed or graded site, restore or protect a minimum of 50% of the site area (excluding the building footprint) with native or adaptive vegetation. Plants indigenous to a locality or cultivars of native plants that are adapted to the local climate are considered as a Native or Adaptive plant; invasive species or noxious weeds are not considered as such. This is similarly applicable to landscaping on rooftops and roof gardens, as long as the plants meet the definition of native or adaptive vegetation.

Provide adequate tree-shaded parking to minimize footprint, avoiding separate paved areas for parking

Plans for replantation to compromise for footprint as reservations or rooftop gardening.

Credit 2.7 – Storm Water Design, Quantity Control

2 Points + 1 Point

Intent

Limit disruption of natural water hydrology ~~by~~ through proper watershed management mechanisms such as reducing impervious cover, increasing on-site infiltration, and managing storm water run-off will result to reduce the risk of flooding and flash flooding.

Requirements

Watershed management modifies formation of floodwater which includes land use and soil conservation to minimize surface runoff, limit erosion and sediment transport by terracing and contour ploughing, reduce impervious cover and enhance on-site infiltration through vegetation cover management and afforestation.

If existing imperviousness is less than or equal to 50%:

Implement a storm-water management plan that prevents the post- development, 2 year, 24 hour peak discharge rate from exceeding the pre- development, 2 year, 24-hour peak discharge rate.

OR

If existing imperviousness is greater than 50%:
Implement a storm water management plan that results in a 25% decrease in the rate & quantity of storm water run-off.
And
Implement a storm water management plan that results in a 50% decrease in the rate & quantity of storm water run-off which will result to reduce floods

Potential Technologies & Strategies

Design the project site to maintain natural storm water flows by promoting infiltration. Specify vegetated roofs, pervious paving, and other measures to minimize impervious surfaces. Reuse storm water volumes generated for non-potable uses such as landscape irrigation, toilet, urinal flushing and other uses.

Credit 2.8 – Storm Water Design, Quality Control

2 Points

Intent

Limit disruption and pollution of natural water flows by managing storm water run-off.

Requirements

Implement a storm water management plan that reduces impervious cover, promotes infiltration and captures and treats the storm water run-off from 70% of the average annual rainfall using best management practices.
The storm water treatment systems shall be designed to remove 80% of the average annual post-development total suspended solids (TSS) based on the average annual loadings from all storms less than or equal to the 2-year/24- hour storm.

Potential Technologies & Strategies

Use alternative surfaces (e.g., vegetated roofs, pervious pavement or grid pavers) and nonstructural techniques (e.g., rain gardens, vegetated swales, disconnection of imperviousness, rainwater recycling) to reduce imperviousness and promote infiltration, thereby reducing pollutant loadings. Use sustainable design strategies (e.g., low impact development, environmentally sensitive design) to design integrated natural and mechanical treatment systems such as constructed wetlands, vegetated filters, and open channels to treat storm water run-off.

Credit 2.9 – Heat Island Effect, Non – Roof

1 Point

Intent

Reduce heat islands (thermal gradient differences between developed and undeveloped areas), minimize the impact on microclimate and human and wildlife habitat.

Requirements

Option 1
Use any combination of the following strategies for 50% of the site hardscape (Including roads, sidewalks, courtyards and parking lots):

- Provide shade from the existing tree canopy or within 5 years of landscaping (trees) must be placed at the time of occupancy.
- Provide shade from architectural devices or structures that have solar reflectance index (SRI) of at least 29.
- Provide grass pavers.

OR

Option 2
Place a minimum of 50% of parking spaces underground or covered by structured parking; that have SRI of at least 29.
Notes:SRI Values of reflectance materials shall be as per ASTM Standards and test certification by a third party agency approved by GBCSL

OR

Option 2
Use an open-grid pavement system (less than 50% impervious) for a minimum of 50% of the parking lot area.

Potential Technologies & Strategies

Shade constructed surfaces on the site with landscape features and utilize high-reflectance materials for hardscape. Consider replacing constructed surfaces (i.e. roof, roads, sidewalks, etc.) with vegetated surfaces such as vegetated roofs and open grid paving or specify high-albedo materials to reduce the heat absorption.

Credit 2.10 – Heat Island Effect, Roof

1 Point

Intent

Reduce heat islands (thermal gradient differences between developed and wildlife habitats.

Requirements

Option 1
Use roofing materials having a Solar Reflectance Index (SRI) equal to or greater than the values in the table below for a minimum of 75% of the roof surface.

Table 2.1: SRI for different slopes

Roof Type	Slope
Low-Sloped Roof Slope	$\leq$ 2:12
Steep-Sloped Roof	$\geq$ 2:12

OR

Option 2
Install a vegetated roof for at least 50% of the roof area.

OR

Option 3
Install high-albedo and vegetated roof surfaces that, in combination, meet the following criteria:

Potential Technologies & Strategies

Consider installing high-albedo and vegetated roofs to reduce heat absorption. SRI is calculated according to ASTM E 1980. Reflectance is measured according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Emission is measured according to ASTM E 408 or ASTM C 1371.

Credit 2.11 – Light Pollution Reduction

1 Point

Intent

Minimize light trespass from the building and site, reduce sky-glow to increase night sky access, improve nighttime visibility through glare reduction, and reduce development impact on nocturnal environments.

Requirements

The project team must comply with one of the 2 options for the interior for interior lighting and the requirement for exterior lighting.

For Interior Lighting

Option 1
Reduce the input power (by automatic device of) all nonemergency interior luminaries with a direct line of sight to any openings in the envelope (translucent or transparent) by at least 50% between 10 pm and 5 am. After- hours override may be provided by a manual or occupant-sensing device provided the override lasts no more than 30 minutes.

OR

Option 2
All non-emergency interior lighting shall be turned off during non-business hours.

AND

For Exterior Lighting

Only light areas as required for safety and comfort. Do not exceed 80% of the lighting power densities for exterior areas and 50% for building facades and landscape features as defined in ASHRAE/IESNA Standard 90.1-2004, Exterior Lighting Section, without amendments.

All projects shall be classified under one of the following zones, as defined in IESNA RP-33, and shall follow all of the requirements for that specific light zone (LZ):

LZ1 - Dark (Park and Rural Settings)
Design exterior lighting so that all site and building mounted luminaries produce a maximum initial luminance value no greater than 0.1 horizontal and vertical lux at the site boundary and beyond. Document that 0% of the total initial designed fixture lumens are emitted at an angle of 90 degrees or higher from nadir (straight down).

LZ2 - Low (Residential Areas)
Design exterior lighting so that all site and building- mounted luminaries produce a maximum initial luminance value no greater than 1.0 horizontal and vertical lux at the site boundary and no greater than 0.1 horizontal lux 3m beyond the site boundary. Document that no more than 2% of the total initial designed fixture lumens are emitted at an angle of 90 degrees or higher from nadir (straight down). For site boundaries that about public rights-of-way, light trespass requirements may be met relative to the curb line instead of the site boundary.

LZ3 - Medium (Commercial / Industrial, High-Density Residential)
Design exterior lighting so that all site and building mounted luminaries produce a maximum initial luminance value no greater than 2.0 horizontal and vertical lux at the site boundary and no greater than 0.1 horizontal lux 5m beyond the site. Document that no more than 5% of the total initial designed fixture lumens are emitted at an angle of 90 degrees or higher from nadir (straight down). For site boundaries that abut public rights-of- way, light trespass requirements maybe met relative to the curb line instead of the site boundary.

LZ4 - High (Major City Centers)
Design exterior lighting so that all site and building mounted luminaries produce a maximum initial illuminance value no greater than 6.0 horizontal and vertical lux at the site boundary and no greater than 0.1 horizontal lux 5m beyond the site. Document that no more than 10% of the total initial designed site lumens are emitted at an angle of 90 degrees or higher from nadir (straight down). For site boundaries that abut public rights-of-way, light trespass requirements may be met relative to the curb line instead of the site boundary.

Potential Technologies & Strategies

Adopt site lighting criteria to maintain safe light levels while avoiding off-site lighting and night sky pollution. Minimize site lighting where possible. Technologies to reduce light pollution include full cut-off luminaries, low-reflectance surfaces and low-angle spotlight

3.0 WATER EFFICIENCY

Prerequisite 1 – Eliminate Potable water consumption for Irrigation and Landscaping

Required

Intent

Eliminate the use of potable water for landscape irrigation.

Requirements

Use only captured rainwater, treated grey water and air conditioner condensate etc. to eliminate all potable water use for site irrigation (except for initial watering to establish plants)

Potential Technologies & Strategies

Perform a soil and climate analysis to determine appropriate landscape types and design the landscape with indigenous plants to reduce or eliminate irrigation requirements. Use high-efficiency irrigation systems and consider using storm water or treated grey water, and/or air conditioner condensate water for irrigation. Note that invasive plants may grow due to the use of grey water for irrigation. Therefore, under no circumstances should encourage colonization of non-indigenous and/or invasive plants.

Credit 3.1 - Use of Alternative Water Sources

1 Point

Intent

Maximize the reduction of potable water consumption for non-potable water requirements during operational stage.

Requirements

Use alternative on-site sources of water (ex. rainwater, and air conditioner condensate, grey water) for non-potable applications (ex., toilet and urinal flushing, custodial uses etc.). The quality of any alternative source of water being used must be taken into consideration based on its application or use.

Credit 3.2 – Use of water saving performances

1 Point

Intent

Reduce the consumption of fresh (potable) water through the application of water saving devices

Requirement

Demonstrate that the use of water efficient devices leads to, an estimated aggregate annual saving of 10%

Exemplary Performance Marks (1)

- Installation of uninterruptible power supply at pumping stations to prevent service disruption during blackouts occurred in emergencies and hazards.
- Installation of emergency shutoff valves at the storage points

Credit 3.3 – Indoor water use reduction

1 – 4 Points

Intent

Optimize the water use efficiency within buildings to reduce the burden on potable water supply and wastewater systems.

Requirements

Employ strategies that use less water than the water use baseline calculated for the building (excluding irrigation). The overall water savings percentage for each point threshold is given in Table 3.1.

Table 3.1: Point thresholds for overall indoor water reduction

Percentage Reduction	Points
20% - 29%	1
30% - 39%	2
40% - 49%	3
50% or above	4

Water reduction through Fixtures, Fittings and Appliances

Calculate the baseline according to the commercial and/or residential baseline outlined as per Tables 3.2 and 3.3. Calculations are based on estimated occupant usage and must include the fixtures and fixture fittings (as applicable to the project scope) such as water closets, urinals, lavatory faucets, showers, kitchen sink faucets and pre-rinse spray valves.

Table 3.2: Current baselines for commercial fixtures fittings and appliances

Commercial Fixtures, Fittings and Appliances	Current Baseline
Commercial toilet	6 liters per flush(lpf) Except blow-out fixtures: 12 (lpf)
Commercial urinals	4.0(lpf)
Commercial toilet (restroom) faucets	9 liters per minute(lpm) at 4 bars, private applications only (hotel or motel guest rooms, hospital patient rooms) 2(lpm) at 4bar all others except private applications 1 liter per cycle for metering faucets
Commercial pre-rinse spray valves (for food service applications)	Flow rate ≤ 6 (lpm) (no pressure specified; no performance requirement)

Lpf – Liters per flush Lpm – Liters per minute

Table 3.3: A current baseline for residential fixtures, fittings & appliances

Residential Fixtures, Fittings and Appliances	Current Baseline
Residential toilet	6 (lpf)
Residential kitchen faucet	8 (lpm) at 4bar
Residential toilet (restroom) faucets	
Residential showerhead	9(lpm) at 5.5bar per shower stall

The following fixtures, fittings and appliances are outside the scope of the water use reduction calculation;

- Commercial Steam Cooker
- Commercial Dishwasher
- Automatic Commercial Ice Maker
- Standard and Compact Residential Dishwashers

Potential Technologies & Strategies

Use high-efficiency fixtures. (e.g. water closets and urinals) and dry fixtures, such as toilets attached to composting systems, to reduce the potable water demand. Consider using alternative on-site sources of water. (e.g. rainwater, and air conditioner condensate, grey water) for non-potable applications (e.g., toilet and urinal flushing, custodial uses). The quality of any alternative source of water being used must be taken into consideration based on its application or use.

Credit 3.4 – Water Efficiency in Air-conditioning System

1 Point

Intent

Limit or eliminate the use of potable water for Air-conditioning make-up.

Requirements

Reduce potable water consumption for air-conditioning make-up by 50%.

Potential Technologies & Strategies

Select water-efficient chillers to reduce water requirement for cooling tower make-up. Estimate the potable water requirement for cooling tower make-up in the water-cooled chillers. Consider use of treated rain water or gray water generated within the site for air-conditioning make-up.

Credit 3.5 – Innovative Wastewater Technologies

1 – 4 Points

Intent

Reduce the generation of wastewater, and potable water demand, while increasing the local aquifer recharge.

Requirements

Credit 3.5.1 Reduce Potable Water Use (1 Point)
Reduce the use of potable water (NWS&DB supplied or similar) for building sewage conveyance by a minimum of 50%

Credit 3.5.2 Reduce Potable Water Use or Treat Wastewater (1 Point)
Treat 100% of wastewater on-site to tertiary standards.

Credit 3.5.3 Harvested Rainwater (2 Points)
Harvested rainwater use in toilet flushing and reduce 75% the use of potable water for toilet flushing.

Exemplary Performance Marks (2)
Harvested rainwater use in toilet flushing and reduce 150% the use of potable water for toilet flushing and other non-portable uses like irrigation which result to collect more storm water and reduce the risk of flooding. Also specify the use or discharge methods of excess harvested water (may a methodology to sell/provide to a neighbor.)

Credit 3.5.4 Aquifer recharge (1 Point)
Balance treated wastewater and harvested rainwater after indoor and outdoor use to be directed to wetlands, recharge wells/pits etc. to increase the local aquifer recharge.

Potential Technologies & Strategies

Consider reusing storm water or grey water for sewage conveyance or on- site wastewater treatment systems (mechanical or natural). Options for on- site wastewater treatment include packaged biological pollutant removal systems, constructed wetlands (with indigenous plants and plants that can bind pollutants in redox insensitive forms), and high-efficiency filtration systems (aerobic or anaerobic).

The plumbing system should be designed to incorporate the separation of grey and black waters.

Rain water management systems should be adopted based on the future climate predictions and rain fall patterns in order to adopt for climate change.

Installation of storm water collection systems which can be integrated to rain water harvesting tanks or storages should be designed and installed to handle greater quantity, intensity and precipitation especially in flood prone areas.

Credit 3.6 – Innovative Water Transmission

1 Point

Intent

Limit the use of non-renewable energy for water transmission

Requirements

Reduce 50% of non-renewable energy consumption in water transmission by using renewable energy including solar wind, low impact hydro and biogas strategies

Potential Technologies & Strategies

In addition to the use of alternative onsite sources of water, use high- efficiency fixtures. (e.g. water closets and urinals). Dry fixtures, such as toilets attached to composting systems, to reduce the potable water demand.

Credit 3.7 - Ground Water Recharge, if Ground Water Sources are Tapped

1 point

Intent

Minimize the negative impacts on the ground water resource due to excessive extraction.

Requirements

Recharge an equal amount of water extracted from the ground water.

4.0 ENERGY & ATMOSPHERE

Prerequisite 1 – Fundamental Building Systems Commissioning

Required

Intent

Verify and ensure that fundamental building elements and systems are designed, installed and calibrated to operate as intended.

Requirements

Implement or have a contract in place to implement the following fundamental best practice commissioning procedures;

- Engage a commissioning agent/team that does not include individuals directly responsible for project design or construction management
- Review owner's project requirements (OPR) and the basis of design (BOD) documentation
- Incorporate commissioning requirements into the construction documents
- Develop and utilize a commissioning plan
- Verify installation, functional performance, training, operation and maintenance documentation
- Complete a commissioning report
- Commission to include the following energy systems:
    - Heating, Ventilation, Air Conditioning, and Refrigeration systems (HVAC&R) and associated controls
    - Lighting and Day lighting systems
    - Renewable Energy Systems
- Develop and utilize a commissioning plan for Lightening Protection

Potential Technologies & Strategies

Engage a Commissioning Authority and adopt a commissioning plan. Include commissioning requirements in bid documents and task the commissioning agent to produce a commissioning report once commissioning activities are completed.

Prerequisite 2 – Minimum Energy Performance

Required

Intent

Establish the minimum level of energy efficiency for the base building and systems.

Requirements

Design the building project to comply with both –

- The mandatory provisions (Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4) of ASHRAE / IESNA Standard 90.1 – 2010 (without amendments)

AND

- The prescriptive requirements (Sections 5.5, 6.5, 7.5, and 9.5) or performance requirements (Section 11) of ASHRAE / IESNA Standard 90.1 – 2010 / (without amendments)

The project should comply with the final version of Code of Practice on Energy Efficient Buildings of Sri Lanka, published by Sustainable Energy Authority (SEA), as and when it is released.

Potential Technologies & Strategies

Design the building envelope, HVAC, lighting and other systems to maximize energy performance. The ASHRAE 90.1-2010 user‘s manual contains worksheets that can be used to document compliance with this prerequisite. For projects pursuing points under EA Credit 1, the computer simulation model may be used to confirm satisfaction of this prerequisite.

Code of practice on Energy Efficient Buildings of Sri Lanka, published by SEA may be used to satisfy this prerequisite in lieu of ASHRAE 90.1-2010. SEA code of practice on energy-efficient building can be found at www.energy.gov.lk/.

Prerequisite 3 – CFC Reduction in HVAC&R Equipment

Required

Intent

Reduce ozone layer depletion.

Requirements

Zero use of CFC-based refrigerants in new buildings HVAC&R systems. When reusing an existing base building HVAC equipment, complete a comprehensive CFC phase-out conversion before project completion.

Existing small HVAC&R units containing less than 225 grams (0.5 pounds) of refrigerants and other equipment such as standard refrigerators, small water coolers and any other equipment with refrigerants less than 225 grams are exempt.

Design HVAC systems based on future climate changes and temperature variances. (Highlight the energy aspect)

Potential Technologies & Strategies

When reusing existing HVAC systems, conduct an inventory to identify equipment that uses CFC refrigerants and adopt a replacement schedule for these refrigerants. For new buildings, specify new HVAC equipment that uses no CFC refrigerants.

Credit 4.1 – Optimize Energy Performances

1-10 Points

Intent

Achieve increasing levels of energy performance above the prerequisite standard to reduce environmental impacts associated with excessive energy use.

Requirements

Select one of the three compliance path options described below. Project teams documenting achievement using any of the three options are assumed to be in compliance with [EA] Prerequisite 2.

Option 1 - Whole Building Energy Simulation (1–10 Points)

Demonstrate a percentage improvement in the proposed building performance rating compared to the baseline building performance rating per ASHRAE/IESNA Standard 90.1-2010 (without amendments) by a whole building project simulation using the Building Performance Rating Method in Appendix G of the Standard.

The project should comply with the final version of Code of Practice on Energy Efficient Buildings published by the Sri Lanka Sustainable Energy Authority, as and when it is released.

The minimum energy cost savings percentage for each point threshold is as follows (Table 4.1);

Table 4.1: Minimum energy cost savings percentage for each point threshold

Energy Cost Savings Percentage	Points Awarded
5%	1
10%	2
15%	3
20%	4
25%	5
30%	6
35%	7
40%	8
45%	9
50%	10

Appendix G of ASHRAE/IESNA Standard 90.1-2010 requires that the energy analysis done for the Building Performance Rating Method include all of the energy costs within and associated with the building project. To achieve points using this credit, the proposed design, (Appendix G of Standard 90.1-2010)

- Must comply with the mandatory provisions (Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4) in Standard 90.1-2010 (without amendments).
- Must include all the energy costs within and associated with the building project.

AND

Must be compared against a baseline building that complies with Appendix G to Standard 90-1-2010 (without amendments). The default process energy cost is 25% of the total energy cost for the baseline building. For buildings where the process energy cost is less than 25% of the baseline building energy cost, the GREEN submittal must include supporting documentation substantiating that process energy inputs are appropriate.

For the purpose of this analysis, process energy is considered to include, but is not limited to, office and general miscellaneous equipment, computers, elevators and escalators, kitchen cooking and refrigeration, laundry washing and drying, lighting exempt from the lighting power allowance (ex., lighting integral to medical equipment) and other (ex., waterfall pumps). Regulated (non-process) energy includes lighting (such as for the interior, parking garage, surface parking, façade, or building grounds, except as noted above), HVAC (such as for space heating, space cooling, fans, pumps, toilet exhaust, parking garage ventilation, kitchen hood exhaust, etc), and service water heating for domestic or space heating purposes.

For [EA] Credit 1, process loads shall be identical for both the baseline building performance rating and for the proposed building performance rating. However, project teams may follow the Exceptional Calculation Method (ASHRAE 90.1-2010 G 2.5) to document measures that reduce process loads. Documentation of process load energy savings shall include a list of the assumptions made for both the base and proposed design while theoretical or empirical information supporting these assumptions.

OR

Option 2 — Prescriptive Compliance Path (4 Points)

Comply with the prescriptive measures of the ASHRAE 50% Advanced Energy Design Guide for Small Office Buildings 2004. The following restrictions apply:

- Buildings must be less than 20,000 square feet.
- Buildings must be office occupancy.
- Project teams must fully comply with all applicable criteria as established in the Advanced Energy Design Guide for the climate zone in which the building is located.

OR

Option 3 - Prescriptive Compliance Path (1 Point)

Comply with the Basic Criteria and Prescriptive Measures of the Advanced Buildings Benchmark™ Version 1.1 with the exception of the following sections: 1.7 Monitoring and Trend-logging, 1.11 Indoor Air Quality, and 1.14 Networked Computer Monitor Control. The following restrictions apply:

- Project teams must fully comply with all applicable criteria as established in Advanced Buildings Benchmark for the climate zone in which the building is located.

Potential Technologies & Strategies

Design the building envelope and building systems to maximize energy performance. Use a computer simulation model to assess the energy performance and identify the most cost-effective energy efficiency measures. Quantify energy performance as compared to a baseline building.

Credit 4.2 – Renewable Energy

1-6 Points + 1 Point

Intent

Encourage and recognize increasing levels of self-supply through renewable technologies to reduce environmental impacts associated with fossil fuel energy use.

Requirements

Credit 4.2.1 Renewable energy usage

Supply at least 1% or more of the building 's total energy use (as expressed as a fraction of annual energy cost) through the use of on-site renewable energy systems other than Solar Photovoltaic technology.

OR

Supply at least 5% of the building's total energy use (as expressed as a fraction of annual energy cost) through the use of Solar Photovoltaic technology.
Points earned for non-solar and solar energy in the following table may be added up to a total of 6 points.

Table 4.2: Points earned for percentage use of on-site renewable energy systems

Percentage of Solar Photovoltaic Energy	Percentage of Renewable Energy (Non Solar PV)	Points Awarded
5%	1%	1
10%	2%	2
20%	4%	3
30%	6%	4
40%	8%	5
50%	10%	6

Credit 4.2.1 Renewable energy usage during emergencies (1 Point)

Supply 100% of the building 's energy use during blackouts and emergency blackouts through solar or/and other renewable energy sources.

Potential Technologies & Strategies

Assess the project for potential renewable energies including solar, wind, geothermal, biomass, hydro, and bio-gas strategies. When applying these strategies, take advantage of the net metering with the local utility.

However, note that due consideration has been given to the increasing ease of applying Solar PV to projects while still continuing to value the impact of non-solar renewable energy sources by creating separate point systems for Solar PV and others technologies.

Use 100% of renewable energy sources such as cogeneration & solar as reliable backup & emergency power sources to be used during blackouts by removing barriers to solar energy and increase the allowable roof areas and possible ways to obtain solar power. Keep Commercial & Residential Building Stairwells, Hallways and emergency exits Lit during blackouts due to natural hazard using solar energy and other reliable renewable energy sources. (According to Fire Regulations by CIDA & By Laws for the fire protection and detection by CMC)

Credit 4.3 – Additional Commissioning

1 Point + 1 Point

Intent

Verify and ensure that the entire building is designed, constructed, and calibrated to operate as intended.

Requirements

In addition to the Fundamental Building Systems Commissioning prerequisite, implement the following additional commissioning tasks;

- Conduct a focused review of the design prior to the construction documents phase.
- Conduct a focused review of the construction documents when close to completion.
- Conduct a selective review of contractor submittals of commissioned equipment. The above three reviews must be performed by a firm other than the designer.
- All buildings situated in hazard prone areas should install reliable backup & emergency power sources and communication systems including Backup Fire & Life Safety Communication systems.
- Develop a re-commissioning management manual.
- Have a contract in place for a near-warranty end or post-occupancy review.
- Conduct relevant structural health monitoring checks of the building structures in specific predetermined periodic time intervals (annually), depending on the location of the building, under the monitoring and targeting the resilience of the buildings to withstand against the natural hazards.

Qualifications of Commissioning Agent:

- Must have documented commissioning process experience on at least two building projects with a similar scope of work. The experience must extend from the early design phase through at least 10 months of occupancy.
- May be a qualified employee of the owner, an independent consultant, or a disinterested subcontractor of the design team.

Potential Technologies & Strategies

Engage the Commissioning Authority (CA) early in project design phases. Task the commissioning agent to conduct project reviews before and after construction documents are complete. The CA must also create a re- commissioning manual for the building and review the project at near- warranty end.

Choose reliable backup & emergency power sources such as Generators, back up batteries, Cogeneration & Solar during Blackouts together with a fire protection & detection system. Keep Commercial & Residential Building Stairwells, Hallways and emergency exits Lit during blackouts due to natural hazard using generators or other reliable energy sources.

All large buildings in flood zones should consider having a backup wireless fire communication system, and new large critical buildings must have backup phone and data connections. Mandate the use of storage batteries with a life of at least eight hours to serve buildings' fire and life safety communication systems.

Credit 4.4 – Ozone Depletion

1 Point

Intent

Reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing the direct contribution to climate change.

Requirements

Option 1

Do not use refrigerants OR

Option 2

Use only refrigerants that have Ozone Depletion Potential (ODP) of Zero and a Global Warming Potential (GWP) of less than 50.

OR

Option 3

Select refrigerants and heating, ventilation, air conditioning, and refrigeration (HVAC&R) that minimizes or eliminates the emission of compounds that contribute to ozone depletion and global climate change. The building HVAC&R equipment must comply with the following formula, which sets a maximum threshold for the combined contributions to ozone depletion and global warming potential:

$$\boldsymbol{LCGWP} + \boldsymbol{LCODP} \times \mathbf{10^5} \leq \mathbf{13}$$

(SI units)

LCGWP	Lifecycle Direct Global Warming Potential (kg CO_2/kW-year)
LCODP	Lifecycle Ozone Depletion Potential (kg CFC 11/(Kw/year))
[( )]	
[( )]	
GWPr	Global Warming Potential of Refrigerants (0 to 12,000 kg CO_2/kg r)
ODPr	Ozone Depletion Potential of Refrigerants (0 to 0.2 kg CFC 11/kg r)
Lr	Refrigerant Leakage Rate (2%)

Mr	End of Life Refrigerant Loss (10%)
Rc	Refrigerant Charge (0.065 to 0.65 kg of refrigerant per Kw OF AHRI or Eurovent rated cooling capacity)
Life	Equipment Life (10 years; default based on equipment type, unless otherwise demonstrated)

For multiple types of equipment, a weighted average of all base building HVAC&R equipment must be calculated using the following formula:

$$\frac{[\sum(\boldsymbol{LCGWP} + \boldsymbol{LCODP} \times \mathbf{10^5}) \times \boldsymbol{Qunit}]}{\boldsymbol{Qtotal}} \leq \mathbf{13}$$

(SI units)

Qunit	Eurovent Certified cooling capacity of an individual HVAC or refrigeration unit (kW)
Qtotal	Total Eurovent certified cooling capacity of all HVAC or refrigeration (kW)

For all Options

Small HVAC units (defined as containing less than 0.25 kg of refrigerant) and other equipment such as standard refrigerators, small water coolers, and any other cooling equipment that contains less than 0.25 kg of refrigerant, are not considered part of the base building system and are not subject to the requirements of this credit Do not operate or install fire suppression systems that contain CFC and hydro chlorofluorocarbons (HCFCs) or halons.

Potential Technologies & Strategies

Design and operate the facility without mechanical cooling and refrigeration equipment. Where mechanical cooling is used, utilize base building HVAC and refrigeration systems for the refrigeration cycle that minimizes direct impact on ozone depletion and global warming. Select HVAC&R equipment with reduced refrigerant charge and increased equipment life. Maintain equipment to prevent leakage of refrigerant to the atmosphere. Utilize fire suppression systems that do not contain HCFCs or Halons.

Credit 4.5 – Measurement & Verifications

1-2 Points

Intent

Provide the building energy consumption performance over time, for the ongoing accountability.

Requirements

Develop and implement a Measurement & Verification (M&V) Plan consistent with

Option 1: (1 Point)
Develop and implement a Measurement & Verification (M&V) Plan consistent with either Option B (ECM Isolation) or Option D (Whole-Building Calibrated Simulation) as specified in the International Performance Measurement & Verification Protocol (IPMVP) Volume III: Concepts and Options for Determining Energy Savings in New Construction, April 2003. The M&V period shall cover a period of no less than one year of post-construction occupancy.

AND/OR

Option 2: (2 Points)
In addition to the M&V plan detailed above, install a centralized Building Management System (BMS) that monitors and records the energy consumption patterns of the building for further analysis and optimization. The BMS must comply with the following requirements:

- Record at intervals of one hour or less
- Must record both consumption and demand
- Whole-building electricity meters should record the power factor
- The system must be capable of reporting hourly, daily, monthly, and annual energy use
- The system must be capable of storing all meter data for at least 36 months

Potential Technologies & Strategies

Develop an M&V Plan to evaluate the building and/or energy system performance. Characterize the building and/or energy systems through energy simulation or engineering analysis. Install the necessary metering equipment to measure energy use. Track performance by comparing predicted performance to actual performance, broken down by component or system as appropriate. Evaluate energy efficiency by comparing actual performance to baseline performance.

While the IPMVP describes specific actions for verifying savings associated with energy conservation measures (ECMs) and strategies, this GREEN credit expands upon typical IPMVP M&V objectives. M&V activities should not necessarily be confined to energy systems where ECMs or energy conservation strategies have been implemented. The IPMVP provides guidance on M&V strategies and their appropriate applications for various situations.

A building management system (BMS) or building automation system (BAS) provides the building operator with a clear picture of the building's energy use over time and may also provide for the automation of many systems. This can lead to energy savings and optimization.

Credit 4.6 – Green Power

1 Point

Intent

Encourage investments in off-site renewable energy technologies for export purposes to the National Grid.

Requirements

Demonstrate that the company has installed green power equivalent to 50% of the total energy requirement of the building, anywhere in the country. This investment should come because of the rated building and should be 50% of the building consumption. Therefore, the green power generated should be counted only once.

Potential Technologies & Strategies

Estimate the energy needs of the building on annual basis. Invest in green power plants in the country, which meets 50% of the total energy requirement of the building. Green power is derived from solar, wind, geothermal, biomass, or low-impact hydro sources.

Credit 4.7 – Certified Energy Auditor

1 Point

Intent

Ensure that a qualified person on staff manage the building energy systems and seek to optimize performance over time.

Requirements

Option 1:
A person on staff designated the energy manager must be a full-time employee of the building or organization and must have been awarded the Energy Manager's certification from the Sustainable Energy Authority (SEA) of Sri Lanka.

OR

Option 2:
Where no certified person on staff can be designated, a third party person with a valid contract for a 1 year, with a commitment to extend up to 3 years can be appointed as the building energy manager.

All Options
The building energy manager must present an annual report on building energy consumption and energy management to building/organizational management team.

Potential Technologies & Strategies

Seek to manage and optimize the building energy management by employing a qualified person, by encouraging an employee to undergo the energy manager training and certification process, or by hiring a qualified 3rd party to meet the requirements.

5.0 MATERIALS & RESOURCES AND WASTE MANAGEMENT

Prerequisite 1 – Storage & Collection of Recyclables Intent

Required

Intent

Facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills.

Requirements

Provide an easily accessible area that serves the entire building and is dedicated to the separation, collection and storage of materials for recycling including (at a minimum) paper, corrugated cardboard, glass, plastics, and metals.

Potential Technologies & Strategies

Coordinate the size and functionality of the recycling areas with the anticipated collections services for glass, plastic, office paper, newspaper, cardboard, and organic wastes to maximize the effectiveness of the dedicated areas. Consider employing cardboard balers, aluminum can crushers, recycling chutes, and collection bins at individual workstations to further enhance the recycling program.

- Facilitate for the collection and storage of different recyclables such as paper, glass, metal and plastic commingled or sorted form.
- Facilities for systems for food waste to be treated and recycled, for buildings generating large volumes of food waste.
- Facilities or systems for the placement of horticultural or wood waste for recycling.
- Monitor the amount and types of wastes collected from each category in weight and/or volumes and amount reused/recycled by each category. (Selling the waste to an outside party would be considered as a reuse process.)

5.0 Materials and Resources

Credit 5.1.1 – Building Reuse

1-2 Points

Intent

Extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste, and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport.

Requirements

Reuse large portions of existing structures during renovation or redevelopment projects:

Credit 5.1.1.1: Maintaining 75% of Existing Building Structure and Shell (1 Points)

Maintain at least 75% (100% total) of existing building structure and shell (exterior skin and framing excluding window assemblies and non-structural roofing material).

Credit 5.1.1.2: Maintaining 75% of Existing Building Structure and Shell and 25% of Non-Shell Areas (2 Points)

Maintain 75% of existing building structure shell (exterior skin and framing excluding window assemblies and non-structural roofing material) AND at least 25% non-shell areas (interior walls, doors, floor coverings, and ceiling systems).

Potential Technologies & Strategies

Consider reuse of existing, previously occupied buildings, including structure, envelope and interior non-structural elements. Remove elements that pose a contamination risk to building occupants and upgrade components that would improve energy and water efficiency, such as mechanical systems and plumbing fixtures. Quantify the extent of building reuse.

Credit 5.1.2 – Resource Reuse

1-2 Points

Intent

Reuse building materials and products in order to reduce demand for virgin materials and to reduce waste, thereby reducing impacts associated with the extraction and processing of virgin resources.

Requirements

Credit 5.1.2.1: for at least 10% of the Building (1 Point)

Use salvaged, refurbished or reused materials, products and furnishings for at least 10% of building materials.

Credit 5.1.2.2: for at least 20% of the Building (2 Points)

Use salvaged, refurbished or reused materials, products and furnishings for at least 20% of building materials.

Potential Technologies & Strategies

Identify opportunities to incorporate salvaged materials into the building design and research on potential material suppliers. Consider salvaged materials such as beams and posts, flooring, paneling, doors and frames, cabinetry and furniture, brick and decorative items.

Refurbishing includes renovating, repairing, restoring, or generally improving the appearance, performance, quality, functionality or value of the product.

Excavated earth and stones shall not be considered under reuse of salvaged materials as they are natural resources.

Credit 5.1.3 Recycled Content

1 Point

Intent

Increase demand for building products that incorporated recycled content materials, therefore reducing impacts resulting from extraction and processing of new virgin materials.

Requirements

Use materials with recycled content such that the sum of pre-consumer and post-consumer recycled content plus one-half of the post-industrial content constitutes at least 10% of the total value of the materials in the project.

Potential Technologies & Strategies

Establish a project goal for recycled content materials and identify material suppliers that can achieve this goal. During construction, ensure that the specified recycled content materials are installed. Consider a range of environmental, economic and performance attributes when selecting products and material

Credit 5.1.4 Local/Regional Materials

1 Point

Intent

Increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the regional economy and reducing the environmental impacts resulting from transportation.

10[5]

Requirements

Use a minimum of 50% of building materials and products that are manufactured[1] locally[2].

Potential Technologies & Strategies

Establish a project goal for locally sourced materials and identify materials and material suppliers that can achieve this goal. During construction, ensure that the specified local materials are installed and quantify the total percentage of local materials installed. Consider a range of environmental, economic and performance attributes when selecting products and materials.

The cost of electrical, mechanical and plumbing equipment, systems and appliances and movable materials and furniture shall not be considered in the total materials cost.

Temporary materials such as materials used for the framework, scaffolding, etc., should not be considered for this credit calculation.

Credit 5.1.5 Rapidly Renewable Materials

1 Point

Intent

Reduce the use and depletion of finite raw, and long-cycle renewable materials by replacing them with rapidly renewable materials.

Requirements

Use rapidly renewable building materials and products (made from plants that are typically harvested within a twenty-year cycle or shorter) for 5% of the total value of all building materials and products used in the project.

Potential Technologies & Strategies

Establish a project goal for rapidly renewable materials and identify products suppliers that can support the achievement of this goal. Consider materials such as bamboo, cotton, insulation, agri-fiber and strawboard. During construction, ensure that the specified rapidly renewable materials are installed.

Credit 5.1.6 Certified Wood and Other Building Materials

1 Point

Intent

Encourage environmentally responsible forest management.
Use certified green building materials, products, certified environmentally friendly products and equipment, so as to reduce dependence on materials that have associated negative environmental impacts.

Requirements

Use a minimum of 50% of wood-based materials certified in accordance with the Department of Forest Conservation and State Timber Cooperation of Environment Ministry for wood building components including, but not limited to structural framing and general dimensional framing, flooring, finishes, furnishings, and non-rented temporary construction applications such as bracing, concrete formwork and pedestrian barriers.

AND (or OR)

Ensure that the project uses at least five passive or active green building materials, products and equipment that are certified by GBCSL under green product labeling program or by a third-party agency approved by the WGBC.

Potential Technologies & Strategies

Establish a project goal for certified wood products and identify products and & suppliers that can achieve this goal. During construction, ensure that the certified wood products are installed and quantify the total percentage of certified wood products are installed.

Consider using certified passive products such as glazing, insulation, paints & coatings, adhesives & sealants, fly ash blocks, cement, concrete, composite wood, housekeeping chemicals, false ceiling materials, flooring materials, furniture, gypsum-based products, high reflective materials & coatings, etc.

Consider using active products such as electrical systems (lighting systems & controls, pumps & motors, etc.), mechanical systems, (unitary air conditioners, etc.), plumbing fixtures (faucets, showers, etc.)

Credit 5.1.7 – Global Warming Potential (GWP) of Buildings

1 Point

Intent

Quantify the Global Warming Potential of a building to reduce the environmental impact due to buildings.

Requirements

- Conduct a Life Cycle Assessment of the project's structure that demonstrates at least a 10% reduction of Global Warming Potential and (GWP) compared to the baseline building.
- GWP should not exceed over 5% than baseline building.

Baseline and proposed building must be of comparable size, function, orientation and operating energy performance as defined in EA prerequisite 2. The service life of the base building and proposed building must be the same and at least 60 years to fully account for maintenance and replacement. Same Life Cycle Assessment tools and datasets must be used for both cases. Data sets must be compliant with ISO 14044.

Estimate the Global Warming Potential (GWP) in kgCO2e for the baseline building and the proposed building using empirical formula published in mainstream literature (e.g. SCI indexed journals) or numerical simulations or physical modelling. Compare the GWP of the proposed building with the baseline building (carbon emission) Formulas can be used to calculate the total carbon dioxide emission of the building at different stages of the building.

$$\boxed{C = C_b + C_u + C_d - C_t}$$

C – *Total Carbon Dioxide Emission* (kgCO_2e)

C_b – *Total Carbon emission at construction stage* (kgCO_2e)

C_u – *Total Carbon emission at operational stage* (kgCO_2e)

C_d – *Total Carbon emission at demolition stage* (kgCO_2e)

C_t – *Total Carbon sequestration by vegetation within the site* (kgCO_2e)

$$\boxed{C_{be} = \sum_i Q_{be,i} . EF_{be,i}}$$

$Q_{be,i}$ – *Quantity of the ith building material* (kg)

$EF_{be,i}$ – *Emission factor for ith building material* (kg/kg)

$$\boxed{C_b = C_{be} + C_{bt} + C_{bp}}$$

C_{be} $- Total\ CO_2\ emission\ by\ building\ material\ production$(kg$CO_2$e)
C_{bt} $- Total\ CO_2\ emission\ by\ building\ material\ transportation$(kg$CO_2$e)
C_{bp} $- Total\ CO_2\ emission\ during\ demolition\ stage$(kg$CO_2$e)

$$\boxed{C_{bt} = \sum_i Q_{bt,i}.EF_{bt,i}\ \ D_i}$$

$Q_{bt,i}$ $- Weight\ of\ the\ ith\ building\ material$ (kg)
$EF_{bt,i}$ $- Emission\ factor\ for\ ith\ building\ material\ transportation\ method(kg/km)$
D_i $- Distance\ from\ the\ production\ site\ to\ the\ construction\ site\ (km)$

$$\boxed{C_{bp} = C_{bp1} + C_{bp2} + C_{bp3}}$$

C_{bp1} $- Total\ CO_2\ emission\ produced\ by\ various\ construction\ crafts$(kg$CO_2$e)
C_{bp2} $- Total\ CO_2\ emission\ produced\ by\ different\ construction\ processes\ during\ the\ construction\ stage\ (kgCO_2e)$
C_{bp3} $- Total\ CO_2\ emission\ produced\ by\ horizontal\ transportation\ occuring\ during\ the\ construction\ stage$ (kgCO_2e)

$$\boxed{C_{bp1} = \sum_i Q_{bp1,i}.EF_{bp1,i}}$$

$Q_{bp1,i}$ $- Construction\ Project\ Quantities$ (kgCO_2e)
$EF_{bp1,i}$ $- OM\ CO_2\ emission\ factor\ for\ the\ construction\ site'\ selectricity\ system$ (kgCO_2e)

$$\boxed{C_{bp1} = \sum_i Q_{bp1,i}.EF_{bp1,i}}$$

$Q_{bp1,i}$ $- Construction\ Project\ Quantities$ (kgCO_2e)
$EF_{bp1,i}$ $- OM\ CO_2\ emission\ factor\ for\ the\ construction\ site'\ selectricity\ system$ (kgCO_2e)

$$C_{bp2} = \sum_i Q_{bp2,i} . EF_{bp2,i}$$

$Q_{bp2,i}$ $-$ *Project Quantity for the ith construction process* (m^3)

$EF_{bp2,i}$ $-$ *Carbon emission factor for the cith construction process* $((\text{kg}CO_2\text{e})/m^3)$

$$C_{bp3} = \sum_i Q_{bp3,i} . EF_{bp3,i}$$

$Q_{bp3,i}$ $-$ ***Horizontal** transportation Project Quantity of the ith building material or equipment* $(\text{kg}CO_2\text{e})$

$EF_{bp3,i}$ $-$ *Carbon emission factor of the ith building material or piece of equipment* $(\frac{kgCO_2e}{kg.km})$

$$C_u = (C_{u1} + C_{u2} + C_{u3}) \times n = (P_{u1} + P_{u2} + P_{u3}) \times EF_{electricity} \times n$$

C_{u1} $-$ *Total* CO_2 *emission generated by air conditioning* $(\text{kg}CO_2\text{e})$

C_{u2} $-$ *Total* CO_2 *emission generated by lighting* $(\text{kg}CO_2\text{e})$

C_{u3} $-$ *Total* CO_2 *emission generated by elevator, office and electrical equipment* $(\text{kg}CO_2\text{e})$

P_{u1} $-$ *Total amount of electricity used by air conditioning* $(MWh/year)$

P_{u2} $-$ *Total amount of electricity used by lighting* $(MWh/year)$

P_{u3} $-$ *Total amount of electricity used by elevator, office and electrical equipment* $(MWh/year)$

$EF_{electricity}$ $-$ *Emission factor for electricty usage in the site* (kg/MWh)

n $-$ *useful lifetime of the building* $(years)$

$$C_t = G_1 \times G_2 \times A \times n \times \frac{44}{12}$$

G_1 $-$ *Carbon ratio of ground tree biomass* $(kg\ carbon\ per\ kg\ drymatter)$

G_2 $-$ *Annual increase in the above ground biomass* $(kg\ dry\ matter/acres.year)$

A $-$ *G reen area* $(acres)$

n $-$ *useful lifetime of the building* $(years)$

$$\boxed{C_d = C_{d1} + C_{d2}}$$

C_{d1} – CO_2 *emission generated during demolition process* (kgCO_2e)

C_{d2} – CO_2 *emission generated during dthe waste material treatment process* (kgCO_2e)

$$\boxed{C_{d1} = A_{gfa} \times EF_{dc} \times EF_{OM}}$$

A_{gfa} – *GFA of the building* (m^2)

EF_{dc} – *Emission factor of the demolition energy consumption for* 10^5 *the reinforced concrete structure* (kWh/m^2)

EF_{OM} – *OM emission factor* ((kgCO_2e)$/MWh$) *(Reference: Changhai Peng,2015)*

$$\boxed{C_{d2} = Q_r \times D_r \times EF_{dr}}$$

Q_r – *Quantity of waste transported to landfills* (kg)

D_r – *Distance between the construction site and landfill* (km)

EF_{dr} – *Emission factor of emissions due to waste transportation* ($kg/kg.km$)

Potential Technologies & Strategies

List the materials and their quantities to be used in the construction and Identify the embodied carbon of the raw materials. Refer the University of bath's Inventory of Carbon and Energy database for required data and LCA software packages such as ATHENA Impact Estimator, ATHENA Eco Calculator, One Click LCA etc.

Credit 5.1.8 – Materials Produced with Waste Materials

1 Point

Intent

Encourage use of materials/products which are up-cycled or down-cycled using waste materials, which results in a reduction of solid wastes to landfills.

Requirements

Consider using up cycled or down cycled waste materials at least for 5% of the total materials requirement, by value.

Potential Technologies & Strategies

When selecting the materials required for the project, consider using materials which include waste materials which are not being recycled in the processes which the wastes are generated. (e.g. Paddy husk, fly ash, wood scraps, sawdust, waste soil/mud)
Examples of such materials: Bricks made out of waste soil/mud, wooden boards made out of processed wood wastes like chips and saw-dust, etc

Credit 5.1.9 – Hazard Resilient Building Materials

1 Point

Intent

Provide the resilience and safety for the building occupants and reduce the economic loss due to building collapses during natural and man-made hazards.

Requirements

Build with hazard resilient & robust building materials which have a high versatility and strength against heavy winds, water pressure due to floods and tsunamis, fire and vibrations due to earthquakes. (Follow NBRO Guidelines in selecting building materials.)

Option 01:
Buildings which are vulnerable to specific hazards should use good quality, hazard resilient & robust building materials for construction.

OR

Option 02:
Buildings which are NOT vulnerable to specific hazards should use good quality, hazard resilient & robust building materials for construction to withstand emergency situations like fires and vibrations.

Potential Technologies & Strategies

Concrete has necessary hardness and mass to resist the heavy winds. Also, it doesn't rot or rust due to floods and is fire resistant. Reinforced concrete framing systems can resist the vibrations and seismic phenomena like most severe earthquakes.

Stone, brick, decay-resistant wood, timber and fiber-reinforced gypsum sheathing are better to resist flood damage. Also, it is favorable to use water resistant and fast recovery materials for internal walls such as concrete block partitions, lime plaster or magnesium oxide board as finishing skirting (NBRO Guideline).

Credit 5.2 Waste Management

Credit 5.2.1 Construction Waste Management

1-2 Points

Intent

Divert construction, demolition, and land clearing debris from landfill disposal redirect recyclable recovered resources back to the manufacturing process. Redirect reusable materials to appropriate sites.

Requirements

Develop and implement a waste management plan, quantifying material diversion goals.

Credit 5.2.1.1 For 50% Recycling (1 Point)
Recycle and/or salvage at least 50% of construction, demolition, and land clearing waste. Calculations can be done by weight or volume but must be consistent throughout.

Credit 5.2.1.2 For 75% Recycling (2 Points)
Recycle and/or salvage an additional 75% of construction, demolition, and land clearing waste. Calculations can be done by weight or volume but must be consistent throughout.

Potential Technologies & Strategies

Establish goals for diversion from disposal in landfills and incinerators and adopt a construction waste management plan to achieve these goals. Consider recycling cardboard, metal, brick, acoustical tile, concrete, plastic, clean wood, glass, gypsum wallboard, carpet and insulation. Designate a specific area(s) on the construction site for segregated or commingled collection of recyclable material, and track recycling efforts throughout the construction process. Identify construction haulers and recyclers to handle the designated materials.

Note that diversion may include the donation of materials to charitable organizations and salvage of materials on-site.

Also, if materials are given to external parties/service providers for recycling or reusing (sold or free), they are also considered for the Credits 5.2.1.1 and 5.2.1.2.

Credit 5.2.2 Operational Solid Waste Management

01 Point

Intent

Ensure effective operational solid waste management, so as to avoid operational (domestic and industrial) wastes being sent to the landfills and to improve sanitation, health and reduce environmental pollution.

Requirement

- The provision of facilities for the collection and storage of 10^5 different common recyclables.
- Buildings with large volumes of food wastes have provisions for food waste management and recycling.

The implementation of the waste management plan shall include built plans highlighting the recycling facilities, the waste collection contracts, methods.

Potential technologies and strategies

Waste management plan detailing the separation of waste expected within the building based on its use.

Layout plan showing the location of the recycling facilities, for the collection and storage of different common recyclables such as paper, glass, metal, plastic.
For buildings with large volumes of organic food waste, the provision systems for the segregation of food waste for separate collection or the provision of an onsite food waste recycling system.

In-house recycling facilities will be able to reduce the landfills and wastes releasing to the environment hence reducing the pressure on the environment. Well managed facilities for the recycling of solid waste encourage recycling and results in reductions in the disposal at landfill sites. Buildings should be designed with the provision of facilities for waste separation and sorting, and short-term storage at appropriate locations. (E.g. Composting facility, Bio-gas facility, etc.)

Credit 5.2.3 Hazardous Waste Management

1 Point + 1 Point

Intent

Facilitate the safe disposal of hazardous waste generated by building occupants which cannot be released to the environment.

Requirements

Take appropriate measures for the safe collection, storage, and disposal of hazardous wastes. (e.g.: batteries, mercury-containing lamps, electronic waste, etc.)

Take appropriate measures to safeguard toxic waste collected and stored in flood prone zones by storing them in a flood proof area or above the elevation of the 50-year flood level which water can't be reached.

Potential Technologies & Strategies

Collect all hazardous waste by identified hazardous elements or category and coordinate with the hazardous waste collection and recycling facilities to carry out necessary actions to mitigate the adverse effects of hazardous wastes by eliminating the release of those wastes to the environment. Characteristic hazardous wastes are materials that are known or tested to exhibit one or more of the following four *hazardous traits:*

- Ignitability
- Reactivity
- Corrosivity
- Toxicity

Hazardous Wastes

- Batteries (e.g. lithium, nickel cadmium, or button cell batteries, dry cells)
- Paints and solvents
- Automotive wastes (used motor oil, antifreeze, etc.)
- Pesticides (insecticides, herbicides, fungicides, etc.)
- Mercury-containing wastes (thermometers, fluorescent lighting, etc.)
- Electronics (computers, televisions, cell phones)
- Aerosols / Propane cylinders
- Caustics / Cleaning agents
- Refrigerant-containing appliances
- Ammunition
- Radioactive Wastes

Methods of management

Safe collection and handing over them to possible recycling plants/waste handling centers

6.0 INDOOR ENVIRONMENTAL QUALITY

Prerequisite 1 – Minimum IAQ Performance

Required

Intent

Establish minimum indoor air quality (IAQ) performance to prevent the development of indoor air quality problems in buildings, thus contributing to the comfort and well-being of the occupants.

Requirements

Meet the minimum requirements of voluntary consensus standard ASHRAE 62.1-2010 Ventilation for acceptable indoor sections 4 through 7, of Air Quality. Mechanical ventilation systems shall be designed using the ventilation rate produce or the applicable local code, whichever is more stringent. Naturally ventilated buildings shall comply with ASHRAE 62.1- 2010 or Local building regulations which are published by Housing and Town Improvement Ordinance No, 19 of 1915 (chapter 268) and Urban Development Authority.

Potential Technologies & Strategies

1.0 Mechanical Ventilated Spaces

Design ventilation systems to meet or exceed the minimum outdoor air ventilation rates as described in the ASHRAE 62.1-2010 and /or Local building regulations which were published by Housing and Town Improvement Ordinance No, 19 of 1915 (chapter 268) and Urban Development Authority standard, whichever is more stringent. Balance the impacts of ventilation rates on energy use and indoor air quality to optimize energy efficiency and occupant health. Use the ASHRAE - 62 User's Manual and Local Building regulations for detailed guidance on meeting the referenced requirements.

2.0 Naturally Ventilated Spaces

For naturally ventilated spaces (and for mixed-mode systems when the mechanical ventilation is inactivated), determine the minimum outdoor air opening and space configuration requirements using the natural ventilation procedure from ASHRAE Standard 62.1–2010 or a local building regulation, whichever is more stringent. Confirm that natural ventilation is an effective strategy for the project by following the flow diagram in the Chartered Institution of Building Services Engineers (CIBSE) Applications Manual AM10, March 2005, Natural Ventilation in Non-Domestic Buildings, Local Building Regulations, whichever is more stringent.

Prerequisite 2 – Smoke (ETS) Control

Required

Intent

Minimize exposure of building occupants, indoor surfaces and ventilation air distribution systems to Environmental Tobacco Smoke (ETS).

Requirements

Option 1

Demonstrate that smoking is prohibited in the any enclosed public places other than,

a) any hotel, guest house or lodge having thirty rooms or more;
b) any restaurant or club having the seating capacity of a minimum of thirty persons;

or

c) an airport,

in accordance with the sec. 39 (1), (2), and (5) of the Act. 27 of 2006 on National Authority on Tobacco and Alcohol (NATA) of PARLIAMENT OF THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA.

OR

Option 2

Prohibit smoking in the building except in designated smoking areas such as

a) any hotel, guest house or lodge having thirty rooms or more;
b) any restaurant or club having the seating capacity of a minimum of thirty persons;

or

c) an airport,

in accordance with the sec. 39 (1), (2), and (5) of the Act. 27 of 2006 on National Authority on Tobacco and Alcohol (NATA) of PARLIAMENT OF THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA.

Locate any designated smoking area within its premises an enclosed space or enclosed area as the case may be, set aside exclusively for smoking. Such area shall be provided with adequate ventilation and shall conform to the prescribed air quality standards.

Locate designated smoking rooms to effectively contain, capture and remove ETS from the building. At a minimum, the smoking room must be directly exhausted to the outdoors with no re-circulation of ETS containing air to the non-smoking area of the building and enclosed with impermeable deck-to-deck partitions. With the doors to the smoking room closed, operate exhaust sufficient to create a negative pressure with respect to the adjacent spaces of at least an average of 5 Pa (0.02

inches of water gauge) and with a minimum of 1 Pa (0.004 inches of water gauge)

Performance of the smoking-room differential air pressures shall be verified by conducting 15 minutes of measurement, with a minimum of one measurement every 10 seconds, of the differential pressure in the smoking room with respect to each adjacent area and in each adjacent vertical chase with the doors to the smoking room closed. The testing will be conducted with each space configured for worst case conditions of transport of air from the smoking rooms to adjacent spaces with the smoking rooms' doors closed to the adjacent spaces.

OR

Option 3 - (For residential buildings only)
Prohibit smoking in all common areas of the building

Locate any exterior designated smoking areas at least 25 feet away from entries, outdoor air intakes and operable windows opening to common areas

Minimize uncontrolled pathways for ETS transfer between individual residential units by sealing penetrations in walls, ceilings and floors in the residential units, and by sealing vertical chases adjacent to the units if the common hallways are pressurized with respect to the residential units then doors in the residential units leading to the common hallways need not be weather-stripped provided that the positive differential pressure is demonstrated as in Option 2 above, considering the residential unit as the smoking room. Acceptable sealing of residential units shall be demonstrated by a blower door test conducted in accordance with ANSI/ASTM-E779-03,

- Standard Test Method for Determining Air Leakage Rate by [105] Fan Pressurization, residential units must demonstrate less than 1.25 square inches leakage area per 100 square feet of enclosure area (i.e. sum of all wall, ceiling and floor areas) AND use the progressive sampling methodology defined in Chapter 4 (Compliance Through Quality Construction) of the Residential Manual for Compliance with California's 2001 Energy Efficiency Standards.

Potential Technologies & Strategies

Prohibit smoking in commercial buildings or effectively control the ventilation air in smoking rooms. For residential buildings, prohibit smoking in common areas, design building envelope and systems to minimize ETS transfer among dwelling units.

Prerequisite 3 - Minimum Acoustic Performance

Required

Intent

Minimize noise and vibration from mechanical and electrical equipment to ensure a basic level of acoustic comfort for occupant health and wellbeing

Requirement

Internal Noise

Achieve a maximum background noise level as per CIBSE Guide A chapter 1.9.3, table 1.15 (CEA does not mention under this category). Follow the recommended methodologies and best practices for mechanical system noise control in CIBSE Guide A, chapter 1.9.3 and the 2011 HVAC Applications ASHRAE Handbook, Chapter 48, Sound and Vibration Control (with errata); AHRI Standard 885–2008;

Exterior Noise

For high-noise sites use noise levels mentioned in Gazette notification no. 924/12 dated 21st may 1996 published by Central Environment Authority Sri Lanka, implement acoustic treatment and other measures to minimize noise intrusion from exterior sources and control sound transmission between buildings spaces. Projects at least one-half mile (800 meters) from any significant noise source (ex., aircraft overflights, highways, trains, industry) are exempt.

Reverberation Time

Adhere to the following reverberation time requirements.

Option 1

For each room, confirm that the total surface area of acoustic wall panels, ceiling finishes, and other sound-absorbent finishes equals or exceeds the total ceiling area of the room (excluding lights, diffusers, and grilles). Materials must have an NRC of 0.70 or higher to be included in the calculation.

OR

Option 2

Confirm through calculations described in ANSI Standard S12.60-2010 that rooms are designed to meet reverberation time requirements as specified in that standard.

Credit 6.1 – Outdoor Air Delivery Monitoring

1 Point

Intent

Provide capacity for ventilation system monitoring to help sustain occupant comfort and well-being.

Requirements

Install permanent CO_2 monitoring systems that provide feedback on ventilation system performance to ensure that ventilation systems maintain design minimum ventilation requirements. Configure all monitoring equipment to generate an alarm when the conditions vary by 10% or more from the set point, via either a building automation system alarm to the building operator or via a visual or audible alert to the building occupants.

For Mechanically Ventilated Spaces

Monitor CO_2 concentrations within all densely occupied spaces (those with a design occupant density greater than or equal to 25 people per 1000 sq. ft.). CO_2 monitoring locations shall be between 1 m and 2 m above the floor.

Calculate appropriate CO_2 set-points using methods in ASHRAE 62.1– 2010, Appendix C.

Naturally Ventilated Spaces

Monitor CO_2 concentrations within all naturally ventilated spaces. CO_2 monitoring shall be located within the room between 1m and 2m above the floor. One CO_2 sensor may be used to represent multiple spaces if the natural ventilation design uses the passive stack(s) or other means to induce airflow through those spaces equally and simultaneously without intervention by building occupants.

Follow CIBSE AM10, Section 4, Design Calculations, to predict that room- by-room airflows will provide effective natural ventilation and /or designed all openings to satisfy the minimum requirement of ventilation mentioned in the UDA building regulations.

Having a mechanism to safeguard indoor air quality from pollutant or hazardous air from out side

Potential Technologies & Strategies

Install CO_2 and airflow measurement equipment and feed the information to the HVAC system and/or Building Automation System (BAS) to trigger corrective action, if applicable. If such automatic controls are not feasible with the building systems, use the measurement equipment to trigger alarms that inform building operators or occupants of a possible deficiency in outdoor air delivery.

Credit 6.2 – Increased Ventilation

1 Point

Intent

Provide additional outdoor air ventilation to improve indoor air quality for improved occupant comfort, well-being and productivity.

Requirements

For Mechanically Ventilated Spaces
Increase breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates required by ASHRAE Standard 62.1-2010 and/or Local building regulations as determined in EQ Prerequisite 1.

OR

Naturally Ventilated Spaces
Design natural ventilation systems for occupied spaces to meet the recommendations set forth in the Carbon Trust ―Good Practice Guide 237‖ [1998],62.1-2010 or Local building regulations.

Determine that natural ventilation is an effective strategy for the project by following the flow diagram process shown in Figure 1.18 of the Chartered Institution of Building Services Engineers (CIBSE) Applications Manual 10: 2005, Natural ventilation in non-domestic buildings and Local building regulations.

AND

Use diagrams and calculations to show that the design of the natural ventilation systems meets the recommendations set forth in the CIBSE Applications Manual 10:2005 and Local building regulations, Natural ventilation in non-domestic buildings

OR

Use a macroscopic, multi-zone, analytic model to predict that room-by-room airflows will effectively naturally ventilate, defined as providing the minimum ventilation rates required by ASHRAE 62.1-2010, for at least 90% of occupied spaces.

Potential Technologies & Strategies

For Mechanically Ventilated Spaces: Use heat recovery, where appropriate, to minimize the additional energy consumption associated with higher ventilation rates.

Naturally ventilated Spaces: Follow the eight design steps described in the Carbon Trust Good Practice Guide 237;

- Develop design requirements,
- Plan airflow paths

- Identify building uses and features that might require special attention
- Determine the ventilation requirements
- Estimate external driving pressures
- Select types of ventilation devices
- Size ventilation devices
- Analyse the design.

Use public domain software such as NIST's CONTAM, Multi-zone Modelling Software, along with LoopDA, Natural Ventilation Sizing Tool, to analytically predict room-by-room airflow

Credit 6.3 – Construction IAQ Management Plan

1 Point

Intent

Prevent indoor air quality problems resulting from the construction/renovation process in order to help sustain the comfort and well-being of construction workers and building occupants.

Requirements

Develop and implement an Indoor Air Quality (IAQ) Management Plan for the construction and preoccupancy phases of the building as follows:

Credit 6.3.1 Construction IAQ Management Plan Before and After Construction (1 Point)

During construction meet or exceed the recommended Design Approaches of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction, 2nd edition, 2007, ANSI/SMACNA 008–2008, Chapter 3.

Protect stored on-site or installed absorptive materials from moisture damage. If air handlers must be used during construction, filtration media with a Minimum Efficiency Reporting. Value (MERV) of 8 must be used at each return air grill, as determined by ASHRAE 52.2–2007

AND

After construction ends and prior to occupancy conduct a minimum two-week building flush-out with new Minimum Efficiency Reporting Value (MERV) 8 filtration media at 100% outside air. After flush-out, new filter with a minimum MERV 8 value, must replace all filters except those solely processing outside air. Note these filters must be MERV 13 or better when a project plans to earn EQ credit 5, Indoor Chemical and Pollutant Source Control.

Potential Technologies & Strategies

Adopt an IAQ management plan to protect the HVAC system during construction, control pollutant sources, and interrupt pathways for contamination. Sequence installation of materials to avoid contamination of absorptive materials such as insulation, carpeting, ceiling tile, and gypsum wallboard. Prior to occupancy, perform a two- week building flush out or test the contaminant levels in the building.

Credit 6.4 – Low - Emitting Materials

1-3 Points

Intent

Reduce the quantity of indoor air contaminants that are odorous or potentially irritating harmful to the comfort and well-being of installer and building occupants.

Requirements

All adhesives and sealants used on the interior of the building (defined as inside of the weatherproofing system and applied on-site) shall comply with the requirements of the reference guide.

Table 6.1: VOC limits for adhesives – architectural applications

Architectural Applications	VOC Limit (g/L) (less water)
Indoor Carpet Adhesives	50
Carpet Pad Adhesive	50
Wood Flooring Adhesives	100
Rubber Floor Adhesives	60
Sub Floor Adhesives	50
Ceramic Tile Adhesives	65
VCT And Asphalt Tile Adhesives	50
Dry Wall and Panel Adhesives	50
Cove Base Adhesive	50
Structural Glazing Adhesives	100
Multipurpose Construction Adhesives	70

Table 6.2: VOC limits for substrate – specific applications

Substrate-Specific Application	VOC Limit (g/L less water)
Metal to Metal	30
Plastic Foams	50
Porous Material (Except Wood) (Except Wood)	50
Wood	30
Fiber Glass	80

Table 6.3: VOC limits for specialty applications

Specialty Application	VOC Limit (g/L less water)
PVC Welding	510
Top and Trim Adhesive	250
Contact Adhesive	80
Special Purpose Contact Adhesive	250

Table 6.4: VOC limits for sealants

10[5]

Sealants	VOC Limit (g/L less water)
Architectural	250
Non-membrane roof	300
Roadway	250
Single-ply roof membrane	450
other	420

Table 6.5: VOC limits for sealant primers

Sealant Primers	VOC Limit (g/L less water)
Architectural, nonporous	250
Architectural, porous	775
Other	750

Credit 6.4.1 Paints and Coatings (1 Point)

Paints and coatings used on the interior of the building defined as inside of the weatherproofing system and applied on-site shall comply with the requirements of the reference guide.

The VOC (Volatile Organic Compounds) content of paints, coatings and primers used must not exceed the VOC content limits mentioned below;

Table 6.6: VOC limits for various paints

Paints	VOC Limit (g/L less water)
Non-flat	150
Mat (fat)	50
Anti-Corrosive / Anti Rust	250

Table 6.7: VOC limits for coatings

Coatings	VOC Limit (g/L less water)
Clear Wood Finishes -	
Varnish	350
Lacquer	550
Floor Coatings	100
Stains	250
Sealers -	
Waterproofing Sealer	250
Sanding Sealer	275
Other Sealers	200

10[5]

Credit 6.4.2 Carpet Systems (1 Point)

Carpet systems must meet or exceed the requirements of the Carpet and Rug Institute's Green Label Indoor Air Quality Test Program. All carpet cushion installed in the building interior shall meet the requirements of Carpet and Rug Institute's Green Label Indoor Air Quality Test Program. All carpet adhesive shall meet the requirements of EQ Credit 6.4.1: VOC limit of 50 g/L.

Credit 6.4.3 Composite Wood and Agri-fiber Products (1 Point)

Composite wood and agri- fiber products used on the interior of the building must contain no added urea-formaldehyde resins. Composite wood and agri- fiber products are defined as particleboard, medium density fibreboard (MDF), plywood, wheatboard, strawboard, panel substrates and door cores.

Potential Technologies & Strategies

Specify low-VOC materials in construction documents. Ensure that VOC limits are clearly stated in each section where adhesives, sealants, paints, coatings, carpet systems, and composite woods are addressed.

Credit 6.5 – Indoor Chemical & Pollutant Source Control

1 Point + 1 Point

Intent

Minimize exposure of building occupants to potentially hazardous particulates and chemical pollutants.

Requirements

Design to minimize and control pollutant entry into building and later cross contamination of regularly occupied areas:

Employ permanent entryway systems at least 2m long in the primary direction of travel to capture dirt and particulates from entering the building at all entryways that are directly connected to the outdoors. Acceptable entryway systems include permanently installed grates, grilles, or slotted systems that allow for cleaning underneath. Roll-out mats are only acceptable when maintained on a weekly basis by a contracted service organization. Qualifying entryways are those that serve as regular entry points for building users.

Where hazardous gases or chemicals may be present or used (including garages, housekeeping/laundry areas, and copying/printing rooms), exhaust each space sufficiently to create negative pressure with respect to adjacent spaces with the doors to the room closed. For each of these spaces, provide self-closing doors and deck – to - deck partitions or a hard lid ceiling. The exhaust rate shall be at least 0.50 cfm/sq. ft, with no air re- circulation. The pressure differential with the surrounding spaces shall be at least 5 Pa (0.02 inches of water gauge) on average and 1 Pa (0.004 inches of water) at a minimum when the doors to the rooms are closed.

In mechanically ventilated buildings, provide regularly occupied areas of the building with air filtration media prior to occupancy that provides a Minimum Efficiency Reporting Value (MERV) of 13 or better. Filtration should be applied to process both return and outside air that is to be delivered as supply air.

Take appropriate measures to safeguard toxic materials stored in flood prone zones by storing them in a flood proof area and above the elevation of the 50-year flood level.

Potential Technologies & Strategies

Design facility cleaning and maintenance areas with isolated exhaust systems for contaminants. Maintain physical isolation from the rest of the regularly occupied areas of the building.

Install permanent architectural entryway systems such as grills or grates to prevent occupant-borne contaminants handling units can accommodate required filter sizes and pressure drops from entering the building. Install high- level filtration systems in air handling units processing both return air and outside air that is to be delivered as supply air.

Credit 6.6 – Controllability of Systems

1-2 Points + 1 Point

Intent

Provide a high level of lighting system control by individual occupants or by specific groups in multi-occupant spaces (i.e., classrooms or conference areas) to promote the productivity, comfort and well-being of building occupants.

Requirements

Credit 6.6.1 Lighting Controls (1 Point)
Provide individual lighting controls for 90% (minimum) of the building occupants to enable adjustments to suit individual task needs and preferences.

AND

Provide lighting system controllability for all shared multi-occupant spaces to enable lighting adjustment that meets group needs and preferences.

Credit 6.6.2 Comfort Controls (1 Point)
Provide individual comfort controls for 50% (minimum) of the building occupants to enable adjustments to suit individual task needs and preferences. Operable windows can be used in lieu of comfort controls for occupants of areas that are 6m inside of and 3m to either side of the operable part of the window. The areas of operable window must meet the requirements of ASHRAE 62.1-2010, paragraph 5.1, Natural Ventilation.

AND

Provide comfort system controls for all shared multi-occupant spaces to enable adjustments to suit group needs and preferences. Conditions for thermal comfort are described in ASHRAE Standard 55- 2010 to include the primary factors of air temperature, radiant temperature, air speed and humidity. Comfort system control, for the purposes of this credit, is defined as the provision of control over at least one of these primary factors in the occupant's local environment.

Credit 6.6.3 Emergency Lighting (1 Point)
Install an emergency lighting control system to keep Commercial & Residential Building Stairwells, Hallways and emergency exits Lit during blackouts due to natural hazard using generators or other reliable energy sources.

Potential Technologies & Strategies

Design the building and systems with comfort controls to allow adjustments to suit individual needs or those of groups in shared spaces. ASHRAE Standard 55-2010 identifies the factors of thermal comfort and a process for developing comfort criteria for building spaces that suit the needs of the occupants involved in their daily activities. Control strategies can be developed to expand on the comfort criteria to allow adjustments to suit individual needs and preferences. These may involve system designs incorporating operable windows, hybrid systems integrating operable windows and mechanical systems, or mechanical systems alone.

Individual adjustments may involve individual thermostat controls, local diffusers at floor, desk or overhead levels, or control of individual radiant panels, or other means integrated into the overall building, thermal comfort systems, and energy systems design. In addition, designers should evaluate the closely tied interactions between thermal comfort (as required by ASHRAE Standard 55-2010and acceptable indoor air quality (as required by ASHRAE Standard 62.1-2010, whether natural or mechanical ventilation)

Credit 6.7 – Thermal Comfort, Design

1 Point + 1 Point

Intent

Provide a comfortable thermal environment that and well-being of building occupants.

Requirements

Design HVAC systems and the building envelope of ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy. Demonstrate design compliance in accordance with the Section 6.1.1 Documentation.

Design HVAC systems based on future climate changes and temperature variances.

Potential Technologies & Strategies

Establish comfort criteria per ASHRAE Standard 55-2010 that support the desired quality and occupant satisfaction with building performance. Design building envelope and systems with the capability to deliver performance to the comfort criteria under expected environmental and use conditions. Evaluate air temperature, radiant temperature, air speed, and relative humidity in an integrated fashion and coordinate these criteria with EQ Prerequisite 1, EQ Credit 1, and EQ Credit 2.

Credit 6.8 – Thermal Comfort, Verification

1 Point

Intent

Provide for the assessment of building thermal comfort over time.

Requirements

Achieve EQ Credit 6.7: Thermal Comfort, Design Agree to implement a thermal comfort survey of building occupants within a period of 6 to 18 months after occupancy. This survey should collect anonymous responses about thermal comfort in the building including an assessment of overall satisfaction with thermal performance and identification of thermal comfort- related problems. Agree to develop a plan for corrective action if the survey results indicate that more than 20% of occupants are dissatisfied with thermal comfort in the building. This plan should include measurement of relevant environmental variables in problem areas in accordance with ASHRAE Standard 55-2004.

Potential Technologies & Strategies

ASHRAE Standard 55-2004 provides guidance for establishing thermal comfort criteria and the documentation and validation of building performance to the criteria. While the standard is not intended for purposes of continuous monitoring and maintenance of the thermal environment, the principles expressed in the standard provide a basis for design of monitoring and corrective action systems.

Credit 6.9 – Daylight & Views

3 Points

Intent

Provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

Requirements

Credit 6.9.1 Daylight (2 Points)

Option 01 - Achieve a minimum Daylight Factor between 2% and 5% (01 Point)

Achieve a minimum Daylight Factor between 2 % and 5 % (excluding all direct sunlight penetration) in 75% of all space occupied for critical visual tasks. Spaces excluded from this requirement include copy rooms, storage areas, mechanical plant rooms, laundry and other low occupancy support areas. Other exceptions for spaces where tasks would be hindered by the use of daylight will be considered on their merits.

Option 02 - Achieve a minimum Daylight Factor over 5% (02 Points)

Achieve a minimum Daylight Factor over 5% (excluding all direct sunlight penetration) in 75% of all space occupied for critical visual tasks. Spaces excluded from this requirement include copy rooms, storage areas, mechanical plant rooms, laundry and other low occupancy support areas. Other exceptions for spaces where tasks would be hindered by the use of daylight will be considered on their merits.

Credit 6.9.2 Views (1 Point)

Achieve direct line of sight to outdoor environment via vision glazing for building occupants in 90% of all regularly occupied spaces. Examples of Exceptions include copy rooms, storage areas, mechanical, laundry and other low occupancy support areas. Other exceptions will be considered on their merits.

Potential Technologies & Strategies

Design the building to maximize day-lighting and view opportunities. Strategies to consider include building orientation, shallow floor plates, increased building perimeter, exterior and interior shading devices, high- performance glazing, and photo-integrated light sensors. Model day-lighting strategies with a physical or computer model to assess foot candle levels and daylight factors achieved.

7.0 INNOVATIONS AND DESIGN PROCESS

7.1 Innovation in Design

1-4 points + 2 Points

Intent

To provide design teams and projects the opportunity to be awarded points for exceptional performance above the requirements set by the GREEN$^{SL®}$ Rating System and/or innovative performance in Green Building categories not specifically addressed by the GREEN$^{SL®}$ Rating System.

Requirements

In writing, identify the intent of the proposed innovation credit, the proposed requirement for compliance, the proposed submittals to demonstrate compliance and the design approach (strategies) that might be used to meet the requirements.

Credit 7.1.1 Innovation in Design (1-2 points)

Achieve significant, measurable environmental performance using a strategy not addressed in GREEN$^{SL®}$ Rating System for Built Environment 2010. Each strategy earns 1 point and up to 2 points in total.

Credit 7.1.2 Exemplary Performance (1-2 points) + (1-2 Points)

Achieve exemplary performance in an existing GREEN$^{SL®}$ Rating System for Built Environment, version 1.0 prerequisite or credit. An exemplary performance may be earned by achieving double the credit requirements and/or achieving the next incremental percentage threshold of an existing credit. Each exemplary performance earns 1 point up to 2 points in total.

Exemplary Performance marks for DRR will also be offered under this credit based on the performance under other categories which were dedicated for exemplary performance.

Potential Technologies & Strategies

Engage a commissioning Authority and adopt a commissioning plan. Include commissioning requirements in large documents and task the commissioning agent to produce a commissioning report once commissioning activities are completed.

8.0 SOCIAL & CULTURAL AWARENESS

Prerequisite 1 – Archeological Sites & Heritage Buildings

Required

Intent

Protect archaeological sites and heritage buildings and discourage building constructions which may affect the cultural identity of the site and the heritage value of the building.

Requirements

Do not develop buildings, roads or parking areas on sites define as archaeological sites without prior approval of the Department of Archaeology. The architectural aspects of the building shall conform to the context of the site. All the building designs within an archaeological site shall be approved by a panel of Qualified Archaeologist and Chartered Architects; jointly appointed by the Department of Archaeology Sri Lanka Institute of Architects.

Do not alter any building identified as heritage buildings by the archaeological department without prior approval. All the buildings design alterations within an archaeological site shall be approved by a panel of Qualified Archaeologist and Chartered Architects; jointly appointed by the Department of Archaeology and Sri Lanka Institute of Architects.

Potential Technologies & Strategies

During site selection avoid developing on archaeologically sensitive sites. All development should conform to the respective heritage policies, laws and regulations;

- Antiquities Ordinance
- Central Cultural Fund Act
- Galle Heritage Foundation Act
- Urban Development Authorities Act
- Housing and Town Improvement Ordinance
- http://www.e.galleheritage.lk
- http://www.archaelogy.gov.lk
- http://www.slia.lk

Credit 8.1 – Social Wellbeing, Public Health & Safety

1 – 2 Points + 2 Points

Intent

Ensure the buildings and developments address the aspects of maintaining and improving the public health and social wellbeing. The social benefits of sustainable design are related to improvements in the quality of life, health, and well-being. These benefits can be realized at different levels; buildings, the community, and society in general. At a building level, research on the human benefits of sustainable design has centered on three primary topics: health, comfort, and satisfaction.

Requirements

Credit 8.1.1 Enhancing social wellbeing and public health [2 Points]

Buildings designed considering the health benefits of an urban lifestyle shall possess the following characteristics;

1. Provide public recreational areas such as parks, lakes etc.
2. Buildings, especially in residential developments in urban contexts, promote walking and cycling for communities.
3. The public safety requirements as per the local authority guidelines in individual and multi-unit buildings as well as large area developments.
4. Building design, layout and planning address the issues of privacy and safety of all types of users.
5. Development should address all levels of accessibility requirements.
6. Provide vegetable garden spaces, vegetable roof gardens to depict the rural lifestyle and our agricultural heritage.

Credit 8.1.2 Enhancing public safety during emergencies [2 Points]

1. Fire Protection & Detection system complied with Fire Regulations by CIDA & by-laws for the fire protection and detection system by CMC.
2. Install a device for lightening protection
3. Maintain an Emergency & First aid Kit to be stored in first floor to be used during an emergency.
4. Design open public spaces in disaster risk areas and in vulnerable building premises which may be in higher elevations to reduce flood risk together with other hazards as well which public can gather during a hazard or an emergency situation as an evacuation place.

Exemplary Performance Marks (3)

Introduce flood, landslide, high wind and Tsunami warning systems and sensors to detect the respective hazards and disseminate early warning alerts.

Potential Technologies & Strategies

During design and planning, a holistic approach should be used, considering residence's rural and agricultural heritage. Development should conform to;

- The Accessibility Guidelines of UDA.
- Local Authority Development Guidelines. (http://www.uda.lk)
- Fire and Safety Regulations of Sri Lanka Fire Department. (http://www.slia.lk)

Emergency & First aid Kit to be stored in first floor to be used during an emergency may contain items such as, water bottle, flashlight (crank or battery-powered and Replace batteries once a year.), emergency operation manual with emergency contacts, a whistle, candles, a match box, and first aid kit, etc.

Series of water sensors are located outside the property and on entry points, linked to an internal remote alarm. Emergency rescue locations are designated at ground and first floor levels. Automation is essential to allow the various technologies to work in synergy and provide early warning, emergency contact and automatic safety measures. External door sensors and internal ground level sensor advises off the presence of water. All sensors are connected to a main sounder to give acoustic and visual warning. Potential to connect the main sounder to an automated call system / emergency authority.

Credit 8.2 – Cultural Identity

1-2 Points

Intent

Make sure the building designs and developments contribute to the cultural identity of the regional, community, locality or neighborhood settings.
In addition to the social benefits, cultural values of a country are also equally important. The culture refers to the cumulative deposit of knowledge, experience, beliefs, values, attitudes, meanings, hierarchies, religion, notions of time, roles, spatial relations, concepts of the universe, and material objects and possessions acquired by a group of people in the course of generations through individual and group striving.
To encourage the use, interpretation and celebration of buildings with cultural heritage.

Requirements

- Justify the building/development designs in terms of the reflection of the cultural values, acceptances, aspirations.
- Promote/provide spaces as required for culturally based life styles of rural and urban settings.
- Create Identity, Sense of Place and Cultural awareness.
- Promote social empowerment, community participation and access.
- Encourage the adaptive re-use and uptake of heritage listed buildings and rewards those that celebrate the heritage value of the asset.
- Demonstrate how the building is occupied or has been significantly refurbished, in such a manner as to celebrate and makes visible heritage elements.
- Make information on the heritage values of the building available to the public visitors to the site through site displays or a context aware smart phone application.

Potential Technologies & Strategies

Development in Cultural cities defined by the Department of Archaeology such as Kandy, Anuradhapura, Polonnaruwa, Dambulla etc. to be followed. The design shall be in accordance with Local authority, Urban Development Authority (UDA) and Department of Archaeology guidelines.

Development should conform to the urban design guidelines of the respective areas approved by UDA. Design buildings with a strong emphasis on the character of the surrounding communities and neighborhoods with cultural importance.

- http://www.archaeology.gov.lk
- http://www.uda.lk
- http://www.slia.lk
- http://www.nppd.gov.lk

- http://www.e.galleheritage.lk

The Project Team shall provide the following required documentation to support the claims made to prove that initiatives have been taken to celebrate the heritage and cultural value of the asset.

- Template outlining the approach taken to celebrate the heritage and cultural value of the asset. The Template shall also enable project teams to provide feedback on the Innovation Challenge to inform future developments.
- Evidence to demonstrate that the asset is indeed of heritage and cultural value.
- Evidence to demonstrate how the site/façade has been refurbished and celebrated as a feature of the building.
- Evidence of information on the heritage values of the building available to public visitors to the site through site displays/context-aware smart phone applications/other.

Annex 2: Transportation Infrastructure Tool of the GREENSL® Rating System for Built Environment Incorporated with DRR and Disaster Resilient Mechanisms

GREENSL® Rating System for Transport Infrastructure
Version 1
Green Building Council of Sri Lanka

GREENSL® Rating System for Transport Infrastructure Development

100 Points Available

1.0 MANAGEMENT (MGT)		
MGT Prerequisite 1	Green Building Accredited Professional	Required
MGT Prerequisite 2	Commissioning Clauses	Required
MGT Prerequisite 3	Infrastructure Users' Guide	Required
MGT Prerequisite 4	Emergency Preparedness Information and Instructions Manual	Required
MGT Credit 1	Environment Management	?
2.0 MOBILITY FOR ALL (MFA)		
MFA Prerequisite 1	Comprehensive Transportation Plan	Required
MFA Prerequisite 2	Choice of Transportation Modes	Required
MFA Credit 1	Transit Facilities	1 – 3 Points
MFA Credit 2	Bicycle Lanes & Pathways	1 – 3 Points
MFA Credit 3	Bicycle Facility Design	1 – 3 Points
MFA Credit 4	Pedestrian Paths & Sidewalks	1 – 4 Points
MFA Credit 5	Pedestrian Facility Design	1 – 5 Points
MFA Credit 6	Safe Pathway Lighting & Design	2 Points
MFA Credit 7	Separation of Modes	1 Point
MFA Credit 8	Conflict Points	1 Point
3.0 TRANSPORTATION PLANNING (TP)		
TP Prerequisite 1	Level of Service	Required
TP Prerequisite 2	Safety Audit	Required
TP Prerequisite 3	Traffic Maintenance Plan	Required
TP Credit 1	Parking Management	1 – 4 Points
TP Credit 2	Optimum Level of Service	2 Points
TP Credit 3	Person-Time & Fuel Usage Savings	2 Points
TP Credit 4	Responsive Traffic Signals	1 – 4 Points
TP Credit 5	Design Speed & Consistency	1 – 2 Points
TP Credit 6	Intelligent Transportation Systems	1 Point
4.0 ENERGY & ATMOSPHERE (EA)		
EA Credit 1	Lighting Energy Efficiency	2 Points
EA Credit 2	Infrastructure Energy Efficiency	2 Points
EA Credit 3	Fossil Fuel & Emission Monitoring	2 – 4 Points
EA Credit 4	Paving Emission Reduction	2 Points
EA Credit 5	Paving Energy Reduction	1 – 3 Points
EA Credit 6	Lightening Protection	?
EA Credit ~~6~~ 7	Volatile Organic Compounds	2 Points
5.0 MATERIALS & RESOURCES (MR)		
MR Prerequisite 1	Construction Waste Management	
MR Credit 1	Lifecycle Costing	3 Points
MR Credit 2	Construction Site Footprint	3 Points
MR Credit ~~3~~ 6	Recycled Content	1 – 6 Points
MR Credit 3	Long Life Pavements	4 Points
MR Credit 4	Local Materials	1 – 2 Points

MR Credit 5	Operational Solid Waste Management	?
MR Credit 7	Hazard Resilient Construction Materials	?
6.0 ENVIRONMENTAL IMPACTS (EI)		
EI Prerequisite 1	Construction Activity Pollution Prevention	Required
EI Prerequisite 2	Construction Site Selection	Required
EI Credit 1	Stormwater Management	4 Points
EI Credit 2	LID Stormwater Management	4 Points
EI Credit 3	Water Efficient Landscaping	1 – 2 Points
EI Credit 4	Reflective Pavement	3 Points
7.0 COMMUNITY IMPACTS (CI)		
CI Prerequisite 1	Community Outreach & Involvement	Required
CI Credit 1	Noise Mitigation Plan	3 Points
CI Credit 2	Traffic Noise Reduction	1 – 4 Points
CI Credit 3	Light Pollution Reduction	3 Points
CI Credit 4	Visual Elements	2 Points
8.0 INNOVATION AND DESIGN (ID)		
ID Credit 1	Innovation & Design Process	1 – 2 Points
ID Credit 2	Exemplary Performance	1 – 4 Points

1.0 MANAGEMENT (MGT)

MGT Prerequisite 1 – Green Building Accredited Professional

Intent

To encourage and recognize the engagement of professionals who can assist the project team with the integration of Green Building aims together with Disaster Risk Reduction (DRR) & disaster resilience mechanisms and processes throughout the design and construction phases.

Requirements

At least two principal participant in the design team should be a Green Building Accredited Professionals engaged by the project owner to provide sustainability & Disaster Risk Management advices from the schematic design phase up to construction completion with his/ her expertise knowledge on green building & sustainability concepts together with Disaster Risk Reduction (DRR) & disaster resilience aspects in the project. The role of the Green Building accredited professional may be fulfilled by different individuals throughout the project based on their expertise. To be deemed engaged, in line with the aim of credit, the Green Building accredited professional must contribute substantially.

The Accredited Green Profession should;

A. Attend at least 50% of project design meetings and 75% of all transportation & infrastructure services meetings
B. Participate in site visits and site meetings at least once a month.

Submittals

1. The evidence of above A and B options must be submitted for each accredited professional.
2. Prepare site inspection report and forward to project consultant/owner/ GBCSL (Specific format to be introduced) by the Accredited Green Profession of the project.
3. Green Rating Proposal Report to be submitted to the GBCSL before construction by the Accredited Green Profession of the project.

Ensure that the submission adheres to all provisions of the submission requirements document found on the GBCSL website.

MGT Prerequisite 2 – Commissioning Clauses

Intent

To encourage and recognize commissioning and handover initiatives to ensure that all transportation infrastructure services can operate to optimum design potential.

Requirements

1. Commissioning and Quality Monitoring

Comprehensive pre-commissioning and quality monitoring are contractually required to be performed for all infrastructure services (BMS, mechanical, electrical and hydraulic); and the works outlined above to be carried out in exact accordance with CIBSE codes or ASHRAE commissioning guidelines (for services only) and CIBSE commissioning codes for the other services.

Also installation and commissioning of fire protection & detection system according to Fire Regulations by CIDA & by-laws for the fire protection and detection system by CMC. Commissioning plan to be included in Green Rating Proposal Report.

2. The collaboration of Design Team and Contractor

The design team and the Contractor are required to transfer project knowledge to the infrastructure owner/manager through the documents of 2, 3, 4, 5 and 6.

3. Architectural & design aspects which can withstand natural hazards specially floods, heavy winds or storms, landslides and tsunamis

- Architectural aspects: Infrastructure plan, Orientation and Shapes
- Design aspects: pavement designs, Infrastructure foundation, superstructure, roof and their combining joints or junctions (Management Commissioning)

4. All transportation infrastructures situated in hazard prone areas should use relevant hazard mitigation & preparedness measures as specified in NBRO Guidelines.

5. Conduct relevant structural health monitoring checks of the building structures, facilities and transportation infrastructure systems in specific predetermined periodic time intervals (usually annually), depending on the location, under the monitoring and targeting the resilience of the infrastructures to withstand against the natural and other hazards.

Submittals

1. A comprehensive report on pre-commissioning and quality monitoring

2. Documented design intent
3. As-built drawings
4. Operations and Maintenance Manual
5. Commissioning Report
6. Training of transportation infrastructure management staff
7. DRR Design and mitigation plan
8. A report on annual health monitoring

MGT Prerequisite 3 – Infrastructure Users' Guide

Intent

Encourage and recognize information management that enables transportation infrastructure users to optimize the infrastructures' environmental performance.

Requirements

A simple and easy-to-use Transportation Infrastructure Users' Guide, which includes information relevant to the infrastructure staff, occupants and tenants 'representatives, is developed and made available to the infrastructure owner. It may contain some useful information that will allow the owners, managers and the staff of the infrastructure facility to understand the reason for some procedures included in the User's Guide.

AND

A separate section/chapter about emergency handling mechanisms during a hazard (including fire hazard) should be incorporated in to the transportation infrastructure users' guide which covers the emergency response in potential hazards.

Submittals

The Transportation Infrastructure Users' Guide must include the following information:

- Energy and Environmental Strategy
- Monitoring and Targeting
- Infrastructure Services (Ventilation, Heating or Cooling systems, Electrical systems and Lighting, etc.)
- Transport Modes and their operations and services (Ventilation, Heating or Cooling systems, Electrical systems and Lighting, etc.)
- Materials and Waste Policies
- Expansion/Re-fit Consideration (Include list if environment recommendations for consideration, highlighting, in particular, the areas covered in the Infrastructure Users' Guide).
- Emergency handling mechanisms and procedures during a hazard (including fire hazard)
- References and Further Information

MGT Prerequisite 4 – Emergency Preparedness Information and Instructions Manual

Intent

Provide safety and emergency preparedness information and instructions for the staff, occupants and passengers of the respective transportation infrastructure system during an emergency or a hazard.

Requirements

Develop an emergency preparedness information and instructions manual for the staff of respective transportation infrastructure system, including model emergency operating procedures and a contact directory.

AND

Develop an emergency preparedness guidelines for the occupants and the passengers of the respective transportation systems including model emergency operating procedures, emergency contact details and evacuation routes and shelters, to be displayed in all transportation infrastructure facilities (transit shelters, bus and train terminals, bicycle parks and public transport vehicles etc.) for the awareness and as an emergency response plan.

And

Maintain an Emergency & First aid Kit to be stored in all transportation infrastructure facilities (transit shelters, bus and train terminals, bicycle parks and public transport vehicles etc.) to be used during an emergency.

Submittals

1. Emergency Preparedness Information and Instructions Manual for staff members should include the following sections,
    - Introduction to the manual
    - Applicable Vulnerable hazards and scenarios
    - Critical Operational Functions, Systems, and Supplies
    - Roles and Responsibilities during a hazard or an emergency
    - Coordinating/Integrating during a hazard or an emergency
    - Evacuation plan (routes, Shelters and stakeholder involvement, etc) including evacuation of disable and people with special health needs during an emergency
    - Contact & safety directory including all emergency contacts
    - Model emergency operating procedures
    - Training and Education
    - Recourses and references

2. A report on emergency preparedness guidelines and actions to be taken for the safety and awareness about the emergency response plan for occupants and the passengers
3. Details of the emergency and first aid kit and its placement in plans

MGT Credit 1 – Environment Management

Intent

Encourage and recognize the adoption of a formal environmental management system in line with established guidelines during construction.

Requirements

Environmental crisis event studies should take into account anticipated climate change conditions for 2020, 2030 and 2060 (or similar time lines based on available data).

Credit 1.1 Involvement of an Ecologist (Point 1)

Involvement of Ecologists at the design stage and obtain a report of survey ecosystems and assess the diversity, profusions and behavior of the different organisms within them relating to the project and their recommendations.

Credit 1.2 Environmental Management Plan (Point 1)

The contractor implements a comprehensive, project-specific environmental management plan (EMP). The contractor should prepare EMP plan before the construction and forward to the GBCSL with the initial proposal. It should include construction dust controlling system, sound controlling system, water pollution controlling in the construction stage and waste management system. *(Specific formats and necessary measuring parameters to be specified by the GBCSL).*

Credit 1.3 Environment Management System (Complying with ISO 14001) (Point 1)

The Contractor has valid ISO 14001 Environmental Management System (EMS) accreditation prior to and throughout the project.

Credit 1.4 Initial Environment Review (IER) and Environment Impact Assessment (EIA)

IER and EIA should be carried out to control the adverse effects and impacts imposed on environment due to new construction being carried out and to ensure that development does not increase the hazard vulnerability of communities, for example through sand mining, or destruction of mangroves.

Submittals

1. Ecologists report
2. A report on EMP
3. A Proof to prove that contract has a valid ISO 14001 EMS
4. EIA report

2.0 MOBILITY FOR ALL (MFA)

MFA Prerequisite 1 – Comprehensive Transportation Plan

Intent

To encourage development and use of comprehensive long-range transportation plans that minimizes excessive bias single occupant vehicles.

Requirements

Project must remain consistent with an overall long-range transportation plan for the community or religion and is based on multi modal transportation (e.g. walking, cycling private vehicle and public transit) principles.

OR

Develop a transportation plan for a community or region, which is based on the use of multi modal transportation (e.g. walking, cycling private vehicle and public transport) principles.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- A copy of the approved long-range transportation plan.

MFA Prerequisite 2 – Choice of Transpiration Modes

Intent

To promote social equity and choices by providing transportation options.

Requirements

Motorized and non-motorized modes of transportation are provided with continuous and clearly defined routes and universal accessibility is provided.

Also, Increase the diversity of the transportation options available in times of crisis.

Submittals

- Provide the submittal template, signed by the accredited green professional, declaring that the requirements have been met.
- A copy of the overall plan showing pedestrian, cyclist and motorized transportation routes.
- A copy of the overall emergency transportation plan including different emergency transportation modes and their respective evacuation routes.
- A list of design standards utilized to meet or exceed the local requirements for universal accessibility.

MFA Credit 1 - Transit Facilities

1 to 3 Points

Intent

To promote the use of Transit systems.

Requirements

Covered and at least partially enclosed transit shelters with a bench and lighting at 50% transit stops on the project. (1 Point)
AND

Covered and at least partially enclosed transit shelters with a bench and lighting at 75% transit stops on the project. (1 Point)
AND
Transit stop signage, seating and transit route information at each transit stop. (1 Point)
AND

Protection of transit systems from hazards by providing and maintaining hazard protection systems for short-term and long-term resiliency such as protecting below ground system vents and entrances from flooding, planning systems for 100 -year floods (ReLi 500) and providing of distributed generation power sources.

Submittals

- Provide the submittal template, signed by the accredited green professional, declaring that the requirements have been met.
- Provide an overall plan showing the location of transit stops and the transit shelter type installed.
- Provide a copy of the design details for the transit stop signage, transit route information ~~and~~ transit shelter types and hazard protection system.

MFA Credit 2 – Bicycle Lanes and Pathways

1 to 3 Points

Intent

To encourage cycling as a mode of transportation.

Requirements

An approved bicycle transportation plan.

OR

Comply with city bicycle transportation plan.

AND

Provide roadway curb lanes and minimum of 0.5 meters wider than the vehicular lane width design criteria to accommodate cyclists. (1 Point)

OR

Provide a continuous designated and marked bicycle lane a minimum of 1.5 meters wide along both sides of the roadway. (3 Points)

OR

Provide a continuous, separate hard surfaced pathway a minimum of 3 meters wide along one side of the roadway. (3 Points)

Submittals

- Provide a submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide a copy of the approved bicycle transportation plan.
- Provide an overall plan showing the location and width of the cycling routes as well as route and regulatory signage and pavement marking as appropriate to the facility provided.

MFA Credit 3 - Bicycle Facility Design

1 to 3 Points

Intent

To encourage cycling as a mode of transportation.

Requirements

Use design elements that improve the safety and ease of operation of a bicycle. These include:

Bridge railings a minimum of 1.4 meters high.

AND

Ramps with curb lips no more than 10mm in height, which do not unnecessarily orientate cyclists into traffic lanes. (1 Point)

AND

Drainage grates with openings narrow and perpendicular to the travel lane. (1 Point)

AND

Provide bicycle accessible push buttons for cross-walks. (1 Point)

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.

MFA Credit 4 - Pedestrian Paths & Sidewalks

1 to 4 Points

Intent

To encourage walking as a mode of transportation.

Requirements

The area is part of a traffic management plan designed to disperse through traffic volumes and reduce traffic speeds through roadway design features, which might include narrower travel lanes, tighter corner curb radii, raised medians, curb bulb outs and landscaping. (1 Point)
AND
Provide continuous, hard surfaced sidewalks a minimum of 1.5 meters wide adjacent to one side of the roadway. (1 Point)

AND

Provide continuous, hard surfaced sidewalks a minimum of 1.5 meters wide adjacent to both sides of the roadway. (1 Point)

OR

Provide continuous, hard surfaced sidewalks a minimum of 1.5 meters wide along both sides of the roadway separated from the edge of roadway by a minimum of 3 meters. (2 Points)

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide a summary of the traffic management plan showing how through traffic volumes and traffic speeds are reduced.
- Provide an overall plan showing the location and width of the sidewalks, crossing locations and related pedestrian crosswalk signage and markings

MFA Credit 5 - Pathway Lighting & Design

1 Point

Intent

To promote the use of multi-use paths and sidewalks with appropriate lighting levels.

Requirements

Lighting levels along multi-use paths and sidewalks should follow the current city or municipalities mandates on pathway lighting.

AND

Emergency pathways along the sidewalks should always have a backup power system to light the lighting systems along the evacuation routes during an emergency situation.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- A lighting plan with supporting calculations to demonstrate compliance with pathway lighting criteria.
- Lighting plan along the evacuation routes and back up lighting system operation procedure

MFA Credit 6 – Safe Pedestrian Paths & Sidewalks

1 Point

Intent

To improve safety of non-motorized modes of transportation.

Requirements

Pedestrians and cyclists are physically separated from motorized transportation by boulevards or non-mountable barriers.

AND

Guidance that defines which mode of transportation has the right-of-way is provided at the intersection of all public roads.

OR

Complete integration of motorized and non-motorized traffic in an area of low speeds.

AND

Evacuation routes are developed as a part of public transportation systems for emergency management planning which leads to use Pedestrian Paths & Sidewalks as evacuation routes during emergencies and hazards.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- An overall plan showing the location of sidewalks and bike paths as well as barriers separating motorized and non-motorized traffic.
- An overall plan showing the pavement markings and signage that provide the regulatory control at the intersection of all public roads.

MFA Credit 7 – Conflict Points

1 Point

Intent

To improve safety of non-motorized modes of transportation.

Requirements

An access control plan to minimize the number of accesses.

AND

Guidance either through design elements or traffic control that defines which mode of transportation has the right-of-way is provided at the intersection of all public roads.

AND

Design a conflict management system to be operated through proper traffic controlling of each modes of transportation during hazards and emergency situations.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- An overall plan showing the consolidation or elimination of existing access points.
- An overall plan showing the pavement markings and signage that provide the regulatory control at the intersection of all public roads.

MFA Bonus Credit – Pedestrian Facility Design

1 Point

Intent

To encourage walking as a mode of transportation.

Requirements

Use streetscape and design elements that improve the safety and quality of walking. These Include:
Grader less than 3%, but sufficient that they avoid pooling water.
AND / OR

Shorten pedestrian crossing distances of roads that reduce exposure times to potential conflicts and better visibility of crossing locations. (1 Point)
AND / OR

Priority crossing measures including pedestrian activated crossing or traffic signals at all major intersections that have reasonable maximum pedestrian waiting times and recognize the appropriate walking speeds of the demographics of the area. (1 Point)
AND / OR

Grade separation of crossing points that offer minimum resistance to pedestrian crossings and high levels of security. (1 Point)
AND / OR

Boulevard landscaping, including a mixture of grass, shurbs and tress that buffer pedestrians from the roadway, but do not create hazards for vehicles or restrict traffic flows. (1 Point)
AND / OR

An integrated streetscape that includes, but is not limited to sidewalks over 3 meters in width, special surfaces such as paving stones, seating areas, decorative pedestrian scale lighting, garbage receptacles, landscaping and guide signage consistent with a theme for the area. (1 Point)

Submittals

- Provide the submittal template, signed by the responsible party, declaring that the requirements have been met.
- A grading plan showing grades along pedestrian routes.
- Pedestrian crosswalk protection warrant calculations and an overall plan showing locations where pedestrian activated crossing signals, traffic signals or grade separated crossings are warranted.
- A pedestrian crossing plan showing where shortened crossing locations, pedestrian activated crossing, traffic signals and separated crossings have been provided.

- Pedestrian signal timing plans along with a rationale for proposed pedestrian crossing times and walking speeds.
- An overall landscaping plan along with details of plantings and cross – sections illustrating the desired buffering effect.
- An overall streetscaping plan illustrating the theme and overall concept along with details of surfacing materials and street furniture.

3.0 TRANSPORTATION PLANNING (TP)

TP Prerequisite 1 – Level of Service

Intent

To encourage a provision of appropriate levels of mobility over the longer term.

Requirements

Provide an initial level of service for the project that is consistent with the goals of the overall long- range transportation plan and which can be maintained through staged implementation of capacity improvements during the course of the planning horizon period.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- A copy of the section of the overall long-range transportation plan outlining mobility objectives and target levels of service.
- A summary of the calculations for the initial design levels of service.
- An outline of the staging plan of future improvements to the project and a summary of the calculations to illustrate how they will maintain the target level of service.

TP Prerequisite 2 – Safety Audit

Intent

To encourage the use of third party safety audits.

Requirements

Undertake a safety audit of the roadway that addresses all modes of transportation

AND

Develop a safety audit for the construction duration.

AND

Undertake a safety audit of the emergency backup systems of the respective transportation infrastructure systems.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide a copy of the safety audit report every 3 months' time during the operation of transportation infrastructure Annex 3: City Tool of the GREENSL® Rating System for Built Environment Incorporated with DRR and Disaster Resilient Mechanisms

TP Prerequisite 3 – Traffic Management Plan

Intent

To prepare traffic management plans during construction and in the occurrence of traffic incidents.

Requirements

A construction management plan that addresses traffic accommodation during the construction period.

AND

An incident management plan that addresses planned and unplanned constraints on capacity.

AND

Traffic accommodation strategy that reduces potential vehicle hour delays due to construction to less than 20% of the baseline estimate.

AND

Develop standard operating procedures for traffic management during early warning and emergency situations along with the regular traffic management plan.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide a copy of the Traffic Management Plan during construction.
- Provide a copy of the incident management plan.
- Provide a copy of the detailed traffic accommodation plan along with documentation summarizing the baseline estimate of vehicle hour delays and the actual vehicle hour delays based on field verified delay studies (e.g. confirmation of modeled queue lengths through field data) after implementation of the plan.

TP Credit 1 – Parking Management

1 to 4 Points

Intent

To avoid a surplus of nearby site and on-street parking, and provides adequate parking for cyclists.

Requirements

Project remains consistent with a parking management plan. (1 Point)

AND / OR

Does not contribute to the parking supply in the area, unless deemed necessary. (1 Point)

AND / OR

Proved easy to use and access, theft resistant (can lock frame and one wheel to stand) bicycle stands or lockers are provided at all key locations and are located in visible, well- trafficked areas, but do not obstruct traffic flows. (2 Point)

AND

Avoid impermeable parking areas as much as possible to increase the amount and rate of storm water infiltration and thereby reduce the risk of flooding.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- A copy of the parking management plan for the project area.
- A summary of how the project contributes to the principles of the parking management plan.

TP Credit 2 – Optimum Level of Service

1 Point

Intent

To encourage a provision of the required roadway capacity without providing excessive or unnecessary capacity.

Requirements

Design elements selected based on providing adequate, but not excessive, roadway capacity, for a 15 to 20 year planning horizon.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- A copy of the section of the overall long range transportation plan outlining mobility objectives and target levels of service.
- An overall plan illustrating the proposed roadway geometry, cross-section and intersection configurations.
- A summary of the calculations for the initial design levels of service and for the 10 to 15-year horizon.

TP Credit 3 – Responsive Traffic Signals

1 to 5 Points

Intent

To encourage the optimization of traffic signals to address different time of day events and provide priority of transit and non-motorized users where appropriate.

Requirements

Use of fully actuated traffic signals. (2 Points)

AND

Traffic signal phasing and timing plans for all major different time of day events. (1 Point)

AND / OR

Transit or non-motorized traffic signal priority measures. (2 Point)

AND

Develop a traffic signal system to be operated during early warning and emergency situations along with the regular traffic signal system.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide an overall plan showing the location of all traffic signals and traffic priority measures.
- Provide a summary of the type of traffic control equipment installed at each location.
- Provide a summary of the traffic volume patterns by time of day and day of week at each signalized intersection.
- Provide a summary of the signal phasing and timing plans to address the traffic volume patterns for each traffic signal.

TP Credit 4 – Intelligent Transportation Systems

2 Point

Intent

To encourage the use of ITS technologies (in addition to Responsive Traffic Signals) to improve mobility without adding capacity and/or improve the efficiency of transit systems

Requirements

Use of proven ITS technologies (2 Points)
Smart transportation networking is adopted for early warning, emergency management and to direct the community for evacuation routes.
Emergency preparedness and post disaster instructions are displayed in all Transportation infrastructure facilities (transit shelters, bus and train terminals, bicycle parks and public transport vehicles etc.) for the awareness of occupants and passengers.
Introduce flood, earthquake and landslide warning systems and sensors in transportation infrastructure facilities and services to detect the respective hazards and disseminate early warning alerts.

Submittals

- Provide a submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Documentation of ITS technologies used and explanation of their benefits to a more sustainable transportation project.

TP Bonus Credit – Person-Time & Fuel Usage Savings

2 Points

Intent

To encourage the use of savings in terms of person-time and fuel usage rather than vehicle time savings in the evaluation of design element options

Requirements

Design element options compared and selected based on optimization of person-time and fuel usage savings rather than use of volume to capacity calculations.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- An overall plan illustrating the proposed roadway geometry, cross-section and intersection configurations.
- A summary of alternative roadway geometry, cross-section and intersection configurations considered.

Calculations based on person-time and fuel usage savings illustrating that alternatives for the key design elements, such as lane configurations, intersection spacing and intersection geometry, were selected based on these criteria.

4.0 ENERGY AND ATMOSPHERE (EA)

EA Credit 1 – Lighting Energy Efficiency

2 Points

Intent

To reduce energy consumption in street-lighting systems and use of back up lighting systems during emergency situations

Requirements

Meet but do not exceed local street-lighting standards or local ordinances, whichever is more stringent.

AND

Keep all transportation infrastructure facilities' and services' (transit shelters, bus and train terminals, bicycle parks, evacuation routes and public transport vehicles etc.) Stairwells, Hallways and emergency exits Lit during blackouts due to natural hazards using generators or other reliable energy sources such as solar or/and other renewable energy sources.

AND

Provide Portable Emergency Lighting by providing the occupants with hand-held lighting equivalent to 6-8 LED diodes in brightness for groups of occupants.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- A site plan indicating the location of any relevant lighting infrastructure.
- An estimate of the baseline energy use for any relevant lighting infrastructure items.
- Documentation through a brief narrative and calculations to demonstrate that the standards were met.
- A comprehensive plan of backup lighting systems to be used during hazards and emergencies.

EA Credit 2 – Infrastructure Energy Efficiency

2 Points

Intent

To reduce pollution from infrastructure energy consumption & provide backup energy requirements during an emergency

Requirements

Design and install any pumping or treatment systems that are included as part of the project, to achieve a 15% reduction in energy use from the baseline energy use.

AND

All transportation infrastructure facilities (transit shelters, bus and train terminals, bicycle parks and public transport vehicles etc.) should install reliable backup & emergency power sources and communication systems including Backup Fire & Life Safety Communication systems to be used during a hazard or an emergency situation. Choose reliable backup & emergency power sources such as Generators, back up batteries, and Renewable sources of energy such as Cogeneration & Solar during Blackouts together with a fire protection & detection system to improve resilience and efficiently mitigate in disaster situations. All transportation infrastructure facilities in flood zones should consider having a backup wireless fire communication system, and all transportation infrastructure facilities must have backup phone and data connections. Mandate the use of storage batteries with a life of at least eight hours to serve infrastures' fire and life safety communication systems.

AND

Smart grids are incorporated to improve energy efficiency, reducing accidents and infrastructure failures during disasters.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide a brief report on actions taken to minimize energy usage and the baseline energy use of infrastructure items used.
- Provide a detailed plan of backup & emergency power sources and communication systems including Backup Fire & Life Safety Communication systems to be used during a hazard or an emergency situation.

EA Credit 3 – Minimizing the Exposure to Emissions Worker

2 Points

Intent

To improve the worker's health by reducing the amount of exposure to paving emissions.

Requirements

Implementing Best Management Practices (BMPs) to reduce worker exposure to paving emissions. (2 Points)

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide documentation that demonstrates a plan and execution for reducing workers emission exposure and effects.

EA Credit 4 – Power Energy Reduction

1 to 3 Points

Intent

To reduce energy consumption at the point of production and placement of product.

Requirements

Employ the use of Best Management Practices (BMPs) to reduce the energy consumption at the point of production and placement.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Submit documentation that shows the type of materials used and the type of pavement used on the project.
- Provide documentation demonstrating the current production and placement energy consumption and comparison to current project.

EA Credit 5 – Volatile Organic Compounds

1 Point

Intent

To reduce pollution from release of volatile organic compounds to the atmosphere

Requirements

Design and use those products that minimize the release of volatile organic compounds into the atmosphere.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- A summary of the products being utilized (asphaltic cement, paint, etc.) that release volatile organic compounds into the atmosphere.
- Documentation through a brief narrative and calculations to demonstrate that a 50% reduction in the release of volatile organic compounds was achieved.
- An estimate of the baseline energy use for any relevant infrastructure items.

EA Credit 6 – Lightening Protection

Intent

To provide safety for transportation infrastructure occupants and passengers from the hazards caused due to lightening

Requirements

Design the lightening protection plan and system to be used and installed in all transportation infrastructure facilities such as transit shelters, bus and train terminals, and bicycle parks, etc.

Submittals

Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.

A plan of the Lightening Protection System

EA Bonus Credit – Fossil Fuel & Emission Monitoring

2 to 4 Points

Intent

To reduce the reliance and use of fossil fuels in construction equipment and work vehicles on road construction projects, as well as address their emission output.

Requirements

Creation and implementation of a fuel-use monitoring plan for all construction equipment and work vehicles. This plan is to record the amount of fuel use for each vehicle type on the project. (2 Points)

AND / OR

Creation and implementation of an emission monitoring plan for all construction equipment and work vehicles. This plan is to record the amount of emission produced by each vehicle type on the project. (2 Points)

Submittals

- A list of the construction equipment and work vehicles used on the project, which is to include the make and model of each vehicle.
- Provide the proper documentation for each plan.
- Provide the proper documentation demonstrating the fuel use and emission outputs of each of the construction vehicles on the site.

5.0 MATERIALS AND RESOURCES (MR)_

MR Prerequisite 1 – Construction Waste Management

Intent

To divert construction and demolition debris from disposal in landfills and incinerators by redirecting recyclable resources back to the manufacturing process and reusable materials to the appropriate sites.

Requirements

Develop and implement a construction waste management plan that recycles and/or salvages non- hazardous construction and demolition debris, excluding vegetation and soils.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide a copy of the construction waste management plan.

MR Credit 1 – Lifecycle Costing

1 Point

Intent

To encourage use of life cycle costing to select products and methodologies

Requirements

Undertake life cycle costing of all significant cost items using an appropriate discount rate including:

- Pipe materials
- Pavement structure
- Structures (bridges and walls)
- Lighting (fixtures and poles)
- Signage (sign and pole)

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide a copy of the life cycle cost assessments, along with the rationale for the selected Discount Rate, for each significant project element. Where a formal life cycle assessment has been used as part of approach to develop an agency policy on an element (e.g. pole types), submission of a signed letter documenting this approach will be considered as acceptable.

MR Credit 2 – Construction Site Footprint

3 Points

Intent

To conserve existing natural areas and vegetation and minimize neighborhood impacts.

Requirement

Locate the project footprint on areas that are 100% previously developed as a transportation corridor. (3 Points)

OR

In areas, where there is no previous development, limit all site disturbances to no more than 5 meters beyond the limits of curbs, shoulders, sidewalks, pathways or utility cuts. (3 Points)

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- An overall plan indicating the location of any areas that are previously developed as part of a transportation corridor, the footprint of the project and the zone of construction impact.

MR Credit 3 – Long Life Pavements

4 Point

Intent

To design of pavement structures intended to perform 30 years or more with minimal restoration of the surface ~~and,~~ reduce future rehabilitation requirements and withstand against natural hazards.

Requirements

Use of a pavement structure with a design life of at least 30 years. (2 Points)

OR

Use of a pavement structure with a design life of at least 40 years. (4 Points)

AND

Exemplary Performance point will be awarded a design life of 50 or more years.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- A copy of the design report summarizing the pavement design principles and inputs, a comparison of pavement designs for traditional "20 year" pavements and a long life pavement design option with a life of at least 30 years and their expected rehabilitation requirements.
- Confirmation of the use of the long-life pavement design option.

MR Credit 4 – Local Materials

1 to 2 Points

Intent

To reduce energy use and vehicle emissions in the transport of materials by encouraging use of local materials.

Requirements

Materials must come to the jobsite from less than 325 kilometers away. One point will be rewarded if at least 50% of the materials come from 325 kilometers away. A second point will be awarded for at least 75% of the materials to come from 325 kilometers away; and an Exemplary Performance point will be awarded for 100% compliance.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- A summary of all major elements and their quantities used in the project (e.g. aggregate, asphaltic cement, cement, street furniture and landscaping materials)
- A summary of available suppliers (not distributors), their location and distance to the project.
- A summary of suppliers utilized and confirmation that they are located within 250 miles of the jobsite.
- Confirmation of the use of the long life pavement design option.

MR Credit 5 – Operational Solid Waste Management

Intent

Ensure effective operational solid waste management and safe disposal of hazardous waste generated which cannot be released to the environment so as to avoid operational wastes being sent to the landfills and to improve sanitation, health and reduce environmental pollution.

Requirements

The provision of facilities for the collection and storage of different common recyclables

AND

The implementation of the waste management plan shall include built plans highlighting the recycling facilities, the waste collection contracts, methods.

AND

Take appropriate measures for the safe collection, storage, and disposal of hazardous wastes. (e.g.: batteries, mercury-containing lamps, electronic waste and toxic waste etc.) with appropriate measures to safeguard hazardous waste collected and stored in flood prone zones by storing them in a flood proof area or above the elevation of the 50-year flood level which water can’t be reached.

Submittals

1. Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
2. A comprehensive plan for solid waste management in respective transportation infrastructure facilities.
3. A plan for hazardous waste management

MR Credit 6 – Hazard Resilient Construction Materials

Intent

Provide the resilience and safety for the transportation infrastructure occupants and passengers and reduce the economic loss due to infrastructure collapses during natural and man-made hazards.

Requirements

Build the transportation infrastructure systems (road pavements, bridges and railways, etc.) and facilities (transit shelters, bus and train terminals and bicycle parks etc.) with hazard resilient & robust construction materials which have a high versatility and strength against heavy winds, water pressure due to floods and tsunamis, fire and vibrations due to earthquakes. (Follow NBRO Guidelines in selecting construction materials.)
Transportation infrastructure systems and facilities which are vulnerable to specific hazards should use good quality, hazard resilient & robust construction materials for construction.

OR

Transportation infrastructure systems and facilities which are NOT vulnerable to specific hazards should use good quality, hazard resilient & robust building materials for construction to withstand emergency situations like fires and vibrations.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide a copy of the list of Construction materials and usage plan

MR Bonus Credit – Recycled Content

1 to 6 Points

Intent

To use recycled materials to reduce the environmental impact of extraction and processing of virgin materials.

Requirements

- Any aggregate base and aggregate sub base shall be 90% by volume recycled aggregate materials, such as crushed asphaltic concrete and Portland cement concrete. (2 points)
- Any asphalt base shall be a minimum 15% by volume recycled asphaltic concrete pavement. (1 points)
- Any asphaltic concrete pavement shall:
    - Be a minimum 15% by volume recycled asphaltic concrete pavement.

  OR
    - Be a minimum 75% by volume rubberized asphaltic concrete pavement from crumb rubber from scrap tires.

  OR
    - Include a minimum of 5% by weight of pre-consumer or post-consumer asphalt roofing shingles. (2 points)
- Any Portland cement concrete shall contain:
    - Recycled mineral admixtures, such as coal fly ash, ground granulated blast furnace slag, rice hull ash, silica fume or other pozzolanic industrial byproduct) to reduce by at least 25% of the concrete mix's typical Portland cement content.

AND

- a minimum of 10% by volume reclaimed concrete material aggregate. (2 points)
- Piping made of Portland cement concrete shall contain recycled mineral admixtures, such as coal fly ash, ground granulated blast furnace slag, rice hull ash, silica fume or other pozzolanic industrial byproduct) to reduce by at least 25% of the concrete mix's typical Portland cement content. (1 points)

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- A table of each material used on the project that is being tracked for recycled content including the type of material and recycled content.

6.0 ENVIRONMENTAL IMPACTS (EI)

EI Prerequisite 1 – Construction Activity Pollution Prevention

Intent

To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, airborne dust generation and limiting the potential for contamination of soils and waterways which also will reduce the risk of occurrence and damage due to natural hazards\

Requirements

Create and implement an erosion and sedimentation control plan for all construction activities associated with the project. The plan shall list the Best Management Practices (BMPs) employed and describe how the BMPs accomplish the following objectives:

- Prevent loss of soil during construction by storm water runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse.
- Prevent sedimentation or contamination of any impacted storm water conveyance systems or receiving streams.
- Prevent contamination of soils.
- Prevent polluting the air with dust and particulate matter.

The BMPs shall be selected from the most stringent guidelines that are applicable to the project.

AND

Implement sediment and erosion control plan which also will reduce the risk of occurrence and damage due to natural hazards due to following aspects;

1. Plant trees for erosion control which have a root system effective at holding back soil as a special strategy for landslide prone areas and trees act as a barrier against heavy winds.
2. Carry out terracing and contour ploughing, vegetation cover management and afforestation for watershed management where as it controls formation of floodwater which includes land use and soil conservation to minimize surface runoff, erosion and sediment transport.

AND

Awards 1 Exemplary Point for obtaining an award/certification for environmental management. (1 Exemplary Point)

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- A copy of the erosion and sedimentation control plan, which includes the source of the BMPs.

- An attestation that the erosion and sedimentation control plan was implemented in accordance with the plan.
- A summary of the monitoring reports for the implementation of the erosion and sedimentation control plan.

Documentation proving that an award or certification has been award for environmental management.

EI Prerequisite 2 – Construction Site Selection

Intent

Avoid developments in inappropriate sites to reduce the environmental impact and to reduce the vulnerability from natural hazards for transportation infrastructure systems on the selected sites.

Requirements

Assess the site condition before design to evaluate sustainable options by site assessment on following;

- Use Hazard Maps and identify the vulnerable hazards and vulnerability level of the site for floods, landslides. Heavy winds and Tsunamis.
- Topography - Contour mapping, unique topographic features, elevation of the land above nearby water bodies can indicate whether the land is vulnerable to floods or inundation, slope of the land to clarify slope stability risk which can result landslides.
- Hydrology - Proximity to drainage paths, waterways, water bodies, lakes, streams, shorelines, delineated wetlands, marsh-lands, coastline and initial water storage capacity of the site would suggest potential of flood hazard areas.

Hazard zoning maps are considered when zoning and layout planning is conducted. Land use restrictions are based on hazard zoning maps and disaster risk assessment data.

You can refer the following authorities to get hazard maps;

- Landslide Hazard Zonation Maps – NBRO Guidelines (https://www.nbro.gov.lk)
- Flood Hazard Maps of the River Basins - Irrigation Department (https://nsdi.gov.lk/department-irrigation)
- The Map of Wind Loading Zones Sri Lanka - NBRO Guidelines (https://www.nbro.gov.lk)
- Coastal Line Vulnerability maps for Tsunamis – Coast Conservation Department (www.coastal.gov.lk)

AND

Do not develop transportation infrastructure systems such as roads, shelters and parking areas, etc. on portions of sites that meet any one of the following criteria:\

- Land that is a prime agricultural land
- Land whose elevation is lower than 1.5m above the elevation of the 50-year flood level
- Land use along the coastal belt shall comply with the guidelines of the Coast Conservation Department (www.coastal.gov.lk)
- Land which is specifically identified as habitat for any species threatened or endangered species by the Department of Wildlife Conservation – Ministry of Environment

- The land is within the specified distance of any wetland shorelines, and bodies of water by providing natural buffer zones, vegetation and soil protection zones as defined by Central Environmental Authority, or as defined by local or state rule or law, or the Ramsar Convention, which is the only global environmental treaty. The most stringent condition will apply.

    - http://www.cea.lk
    - http://www.ramsar.org
    - http://dw.iwmi.org/wetland

- Land which is prior to acquisition for the project was public parkland

AND

Although preference is given to brownfield sites in site selection, compact development is governed by strictly enforced ordinances/regulations. Therefore, planning approval should be given only after carefully considering the hazard risks in brownfield sites.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Site Assessment report
- A site plan which proves the avoidance of above-mentioned environmental conditions

EI Credit 1 – Storm water Management

4 Points

Intent

To protect and enhance the water quality of receiving watercourses, prevent flooding, and promote the public security and economic wellbeing.

Requirement

Rain water management systems and drainage capacities should be adopted based on the future climate predictions and rain fall patterns (In order to adopt for climate change)

Installation of storm water collection systems which can be integrated to rain water harvesting tanks or storages should be designed and installed to handle greater quantity, intensity and precipitation In flood prone areas as well as connected to the transportation infrastructures like road pavements. These storm water collection tanks can be installed as underground mini reservoirs depending on the rainfall data of the area which can reduce greater amount of flood hazards in urban areas while using the collected rainwater for irrigation purposes and toilet flushing of infrastructure facilities.

AND

Implement a comprehensive storm water management plan for the project, with the use of possible Best Management Practices (BMPs) to achieve the water quality and quantity control objectives, such as;

- Source control BMPs involving street sweeping, catch basin cleaning and creating site depression storage and increasing infiltration;
- Conveyance system BMPs using pervious pipe, catch basins plus grassed swales;
- End-of-Pipe BMPs using pond and wetland systems, infiltration and filtrations plus oil/grit separators.

Key criteria are to be evaluated on a site basis:

- Maximum allowable discharge rates to receiving watercourses are to be met;
- Maximum release rates to downstream storm sewer are to be satisfied;
- The removal of Total Suspended Solids (TSS) is to be in accordance with local guidelines with respect to stormwater quality treatment facilities;
- Overland flows are to be in accordance with local guidelines with respect to ponding depth and flow velocities in streets.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant , declaring that the requirements have been met.

- An overall plan illustrating the project's potentially impermeable areas, the location of any stormwater management facilities and/or Best Management Practices.
- A calculation illustrating the effectiveness of the project's selected BMPs, including runoff estimation, storage and water quality improvement.
- Calculation and relevant designs of rainwater harvesting systems

EI Credit 2 – LID Stormwater Management

4 Points

Intent

To encourage use of Low Impact Development (LID) stormwater management strategies that manage runoff at its sources, reduce stormwater conventional construction and maintenance cost, and reducer runoff volume and pollutant loadings.

Requirements

Evaluate project site for LID opportunities and suitability;

Incorporates LID storm water management strategies that meet the storm water regulations of permitting agencies, and reduce runoff volume and promote infiltration through possible practices and available techniques, such as,

- Maintain natural drainage through minimize the right-of-way to accommodate travel lanes, shoulder lanes, slopes, etc.;
- Remove curb and gutters from roads wherever possible, by using vegetated swale conveyance systems instead of enclosed pipe systems, or utilizing an urban curb cut and swale systems;
- Build concave medians or possible depression storages to create bio retention area;
- Use permeable pavements (e.g. porous asphalt, porous pavers, porous concrete) instead of conventional impervious surfaces;
- Amended or engineered soils instead of conventional compacted soils.
- The average annual reduces the average annual post development runoff volume from the project right of way by at least 50%.

AND

Limit disruption of natural water hydrology through proper watershed management mechanisms such as reducing impervious cover, increasing on-site infiltration, and managing storm water run-off will result to reduce the risk of flooding and flash flooding. Watershed management modifies formation of floodwater which includes land use and soil conservation to minimize surface runoff, limit erosion and sediment transport by terracing and contour ploughing, reduce impervious cover and enhance on-site infiltration through vegetation cover management and afforestation.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant , declaring that the requirements have been met;
- Provide lists of LID strategies selected for the project;
- Provide calculations showing the percentage of pervious ratio within the project;

- Provide calculations illustrating the percentage of runoff volume reduction from the project right-of-way by using LID practices;
- Provide reduced capital costs due to the use of LID practices compared to conventional methods associated with construction and maintenance of the project

EI Credit 3 – Water Efficient Landscaping

1 to 2 Points

Intent

To minimize water use for landscape irrigation, where irrigation is warranted, to reduce the impact to natural water resources and burden on municipal water supply and wastewater supply.

Requirements

For irrigation, use only captured and harvested rainwater, recycled wastewater, recycled grey water, or water treated and conveyed by a public agency specifically for non-potable uses. (1 Point) (No portable water usage for non-portable uses like irrigation and toilet flushing)

OR

Select native species to use for roadway landscaping that do not require the need for irrigation after 6-months. (2 Points)

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- A brief narrative describing the landscaping and irrigation design strategies employed by the project.
- The project's baseline and actual water use, after implementation of reduction strategies.

EI Credit 4 – Reflective Pavement

3 Points

Intent

To reduce heat island effects and minimize temperature of storm water runoff by using highly reflective pavements.

Requirements

Use a light colored/high albedo pavement of a minimum of .3 (according to ASTM E 903 test procedures) that will cover a minimum of 50% of the total project hardscape footprint.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide documentations that provide the albedo level of the surface layer, which meets the ASTM E 903 test standards and procedures.

7.0 COMMUNITY IMPACTS (CI)

CI Prerequisite 1 – Community Outreach & Involvement

Intent

To encourage community participation in the project planning and design and involve people who will be impacted by the project in improving the project.

Requirements

A community outreach and involvement program that includes a range of consultation strategies and respects input from community stakeholders during the design and construction phases of the project.

AND

Information and details on local risk, risk management strategies are incorporated into public awareness programs.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide a copy of the written community outreach and involvement program for both the design and construction components of the project.
- Provide a brief narrative describing the steps taken in implementing the community outreach and involvement program and how the program influenced the final design.

CI Credit 1 – Noise Mitigation Plan

3 Points

Intent

To encourage the reduction of noise levels associated with construction activities.

Requirements

A noise mitigation plan that includes a description of construction activities, illustrates the expected noise levels at the affected areas with a noise map.

AND

Implementation of specific mitigation strategies.

Submittals

- Provide a submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide a copy of the noise mitigation plan and how it is to be implemented. It should include documentation showing the mitigation strategies that are being put to use and how they help lessen the impact that construction noise has on the surrounding areas.

CI Credit 2 – Traffic Noise Reduction

1 to 3 Points

Intent

To encourage the reduction of noise levels associated with motorized traffic.

Requirements

A traffic noise study using an accepted methodology and software that calculates existing noise levels, projected noise levels at the completion of the project and projected noise levels at the projected traffic volumes at the 10 and 20 year horizons for all affected non-commercial areas.

AND

Implementation of a noise mitigation strategy that maintains traffic noise levels through all affected non-commercial areas through to the 20 year horizon at no more than existing levels. (1 point)

AND

Implementation of a noise mitigation strategy that reduces traffic noise levels above 65 dBA through all non-commercial areas through to the 20 year horizon to less than 65 Dba. (1 point)

AND

Implementation of a noise mitigation strategy that reduces traffic noise levels above 65 dBA through all non-commercial areas through to the 20 year horizon to less than 60 dBA. (1 point)

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- Provide a copy of the noise study, which illustrates the non-commercial areas affected by the project, existing and projected noise levels and the impacts of the selected mitigation strategy.
- Provide detailed design drawings showing the how the noise mitigation strategy is implemented. Where the strategy involves construction methodologies, such as the use noise reducing pavements or sound absorbing walls, additional product technical data on the methodology to outline its effectiveness is also to be submitted.

CI Credit 3 – Light Pollution Reduction

3 Points

Intent

To minimize light trespass from the project, reduce sky-glow to increase night sky access, improve nighttime visibility through glare reduction, and reduce development impact on nocturnal environments.

Requirements

To follow the guidelines for IESNA TM-10, IESNA TM-11 and IESNA RP-8 Annex C

Submittals

- Provide the LEED submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- An overall plan showing the lighting sources.
- A statement as to the lighting zone(s) that the project is in.
- Design lighting drawings that show the design strategies and/or technologies used to reduce light pollution.

CI Credit 4 – Visual Elements

2 Points

Intent

To encourage transportation corridors that offer views and features that are architecturally compatible with their surroundings, provide aesthetic unity and coherence and improve the experience of passing through the corridor.

Requirements

Use geometries, streetscape and design elements that provide an improved experience at appropriate scales for motorized and on-motorized modes. These include:

Landscaping, including a mixture of grass, shrubs and trees, at scales that are suitable for the different modes of transportation using the project.

AND

An integrated streetscape that includes, but is not limited to special surfaces such as paving stones, decorative poles, decorative lighting and banners. (1 point)

AND

A geometric alignment that provides opportunities to provide varying and significant views for both motorized and non-motorized modes and blends into the surrounding landscape through a curvilinear alignment and appropriate side slopes. (1 point)

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- An overall inventory of existing visual resources and plantings, improvement opportunities and the approach utilized to maximize these opportunities.
- An overall landscaping plan along with details of plantings.
- An overall streetscaping plan illustrating the theme and overall concept along with details of surfacing materials and street furniture.
- An overall plan showing all vertical structures and those structures with specific architectural treatment.
- Detail design drawings of the architectural treatments on vertical structures.
- An overall plan showing significant natural and man-made views of interest and illustrating how the geometric alignment and side slopes have been optimized to provide opportunities for motorized and non-motorized modes to take advantages of those views in a manner that respects the existing landscape.

8.0 INNOVATION DESIGN (ID)

ID Credit 1 – Innovation & Design Process

1 to 2 Points

Intent

To reward innovative ideas, practices and technologies, not specified in the Green Guide. To continue the green movement, and applications of this Guide.

Requirements

Identify the intent of the proposed innovation credit, the proposed requirement for compliance, proposed submittals to demonstrate compliance, and the design approach and strategies that might be used to meet the requirements. (1 point each, up to 2 points)

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant, declaring that the requirements have been met.
- The specific title for the ID credit, a statement of the credit intent, and a statement of the credit requirements.
- A narrative and overall plan describing the project's approach to achievement of the credit, including a description of the quantifiable environmental benefits of the credit proposal.
- Detailed plans and specifications, as necessary to illustrate the project's approach to this credit.

ID Credit 2 – Exemplary Performance

1 to 4 Points

Intent

To reward exemplary performance in the application of credits with-in the Green Guide. To give bonus credits to those who step beyond the minimum requirements for allotted credits.

Requirements

Identify where exemplary performance has been achieved, and demonstrate the strategies and approach used to exceed the minimum requirements. (1 to 4 Points awarded for each applicable credit)

AND / OR

Identify what categories have achieved exemplary performance, a category receiving 90%, or higher, of its possible point totals can receive 1 exemplary performance point. (1 to 4 Points awarded for each applicable category)

Note that 4 Points are the maximum number of points allotted, exceeding requirements in more than four areas will not result in additional points.

Submittals

- Provide the submittal template, signed by the Accredited Green Consultant , declaring that the credit requirements have been met and exceeded.
- Detailed plans and specifications, as necessary to illustrate the project's approach to this credit.

Annex 3: City Tool of the GREENSL® Rating System for Built Environment Incorporated with DRR and Disaster Resilient Mechanisms

<u>SUSTAINABLE CITIES</u>

VERSION 1.0

GREENSL® RATING SYSTEM FOR GREEN AND SMART CITIES CHECKLIST

100 POINTS AVAILABLE

Criteria		Points
1.0 Management Points available		**4**
Prerequisite 1	Green Building Accredited Professionals	Required
Prerequisite 2	The Professional Team	Required
Prerequisite 3	Ensure Public Involvement	Required
Credit 1.1	The Rationale	2 Points
Credit 1.2	Work Plan	2 Points
2.0 Cityscape & Spatial Structuring Points available		**13**
Prerequisite 1	Location	Required
Prerequisite 2	Boundaries and Population	Required
Prerequisite 3	Local Administration and availability of a Development Plan	Required
Credit 2.1	Zoning and Land Use	2 Points
	Credit 2.1.1 Promotion of Sustainable Development	1 Point
	Credit 2.1.2 Protect and Preservation	1 Point
Credit 2.2	Access and Mobility	2 Points
	Credit 2.2.1 Improving Permeability within built fabric	1 Point
	Credit 2.2.2 Encourage Use of Public Transport	1 Point
Credit 2.3	Image Ability	3 points
	Credit 2.3.1 Vistas and Areas of Scenic beauty	1 Point
	Credit 2.3.2 Land Marks	1 Point
	Credit 2.3.3 Aesthetic Control	1 Point
Credit 2.4	Public Space Network	3 points
	Credit 2.4.1 Integration of Public Space Network	1 Point
	Credit 2.4.2 Aesthetic Appeal	1 Point
	Credit 2.4.3 Cultural Integration	1 Point
Credit 2.5	Building Typology and Energy Efficient Architecture	3 Points
	Credit 2.5.1 Building Typology	1 Point
	Credit 2.5.2 Control of Heat Island Effect	1 Point
	Credit 2.5.3 Energy Efficient Architecture	1 Point
3.0 Preservation & Protection of Eco-systems Points available		**14**
Prerequisite 1	Green Cover	Required
Prerequisite 2	Inventory of Native Flora and Fauna	Required
Prerequisite 3	Blue Features	Required
Credit 3.1	Increase Green Cover	3 Points
	Credit 3.1.1 Per Capita Green Cover	2 Points

	Credit 3.1.2 Strategies to Increase Green Cover	1 Point
Credit 3.2	City Landscaping	3 Points
	Credit 3.2.1 Approach to City Landscape and Community Benefits	1 Point
	Credit 3.2.2 Facilitating Green Transport Network	1 Point
	Credit 3.2.3 Reducing Heat Island Effect Through Greenery	1 Point
Credit 3.3	Protection of Natural Resource Base	2 Points
	Credit 3.3.1 Conservation of Natural Resource Base	1 Point
	Credit 3.3.2 Enhance Natural Resource Basic	1 Point
	Credit 3.3.3 Revitalization	
Credit 3.4	Climate Resilience	3 Points
	Credit 3.4.1 Adopt Climate Sensitive Landscape Design	1 Point
	Credit 3.4.2 Community Action to Protect Environmental Sensitivity	1 Point
	Credit 3.4.3 Conducting Public Awareness Program	1 Point
Credit 3.5	Development of Environmentally Degraded Areas	3 Points
	Credit 3.5.1 Improve and Integrate Environmentally Degraded Areas	2 Points
	Credit 3.5.2 Eliminate Causes	1 Point
	Credit 3.5.3 Revitalization	1 Point
4.0 Promoting Sustainability in Economic Development 8 Points available		
Prerequisite 1	The economic base of the City	Required
Prerequisite 2	Resource base of the City	Required
Prerequisite 3	Land profile of the City	Required
Credit 4.1	Sustainability as a key economic driver	2 Points
Credit 4.2	Creating a Circular Economy	2 Points
Credit 4.3	Balancing Corporate Strategy & Corporate Social Responsibility	2 Points
Credit 4.4	Promotion of Sustainable Products & Services	2 Points
5.0 Provision of Sustainable Infrastructure 27 Points available		
Prerequisite 1	Energy Audit	Required
Credit 5.1	City & Energy	10 Points
	Credit 5.1.1 Encourage to Use of Renewable Energy	
	Credit 5.1 .2 Greenhouse Gas Emission Management	
Credit 5.2	City & Water	8 Points
	Credit 5.2.1 Water Conservation	
	Credit 5.2.2 Innovative Transmission of Water	
	Credit 5.2.3 Water System Performance ,Rainwater Harvesting &Storm water Management	
	Credit 5.2.4 Waste water Management &Waste water Treatment	
	Credit 5.2.5 Re-use treated waste water	
Credit 5.3	City Traffic & Transport Network	10 Points

	Credit 5.3.1 Transport policy initiatives to improve performance	
	Credit 5.3.2 Actions taken to increase dependency on public transport and non-Motorized Transport	
	Credit 5.3.3 Parking Policy and Traffic Management	
	Credit 5.3.4 Improve road safety and safety of pedestrians and cyclists	
	Credit 5.3.5 Encouraging Mixed Use & Transit Oriented Development (TOD)	
6.0 Resource Management Points available		**8**
Prerequisite 1	Waste Profile	Required
Prerequisite 2	Waste Management Plan	Required
Credit 6.1	Waste Management	4 Points
	Credit 6.1.1 Management of Liquid, Gaseous & Solid Waste	2 Points
	Credit 6.1.2 Strategies adopted for waste management	2 Points
Credit 6.2	Pollution Management	4 Points
	Credit 6.2.1 Management of Noise, Odour & Visual Pollution	2 Points
	Credit 6.2.2 Management of Air Pollution	1 Point
	Credit 6.2.3 Management of Water Pollution	1 Point
7.0 Provision of Social Infrastructure Points available		**4**
Prerequisite 1	Demographic Assessment	Required
Credit 7.1	Access to Education	2 Points
Credit 7.2	Availability of Healthcare Facilities	2 Points
8.0 Provision of Cultural Integration Points available		**6**
Prerequisite 1	Marked City Plan	Required
Credit 8.1	Ensuring equality and social justice to all citizens	2 Points
Credit 8.2	Cultural integration of communities	2 Points
Credit 8.3	Heritage Management & Place Making	2 Points
9.0 Global Impact on Local Initiatives Points available		**6**
Credit 9.1	Impact of environmental improvements	2 Points
Credit 9.2	Delivering UN sustainability goals	2 Points
Credit 9.3	Recognition of accredited green initiatives	2 Points
10.0 Innovation in Sustainability & Resilience Points available		**10**
Credit 10.1	Adoption Of New Technology For Sustainability	3 Points
Credit 10.2	Developing Business Models For Clean Tech	3 Points
Credit 10.3	Innovative Climate Change Management	2 Points
Credit 10.4	Innovative Intervention For Attitude Change On Sustainable Environment	2 Points
11.0 Management & Monitoring of The Transformation of City Profile Points available		**4**

Prerequisite 1	City Profile	Required
Prerequisite 2	A management Cell	Required
Credit 11.1	Positive changes in the City Transformation	1 Point
Credit 11.2	Improving the Environmental Performance	1 Point
Credit 11.3	Changing Attitudes towards green action	1 Point
Credit 11.4	Management & Monitoring mechanism	1 Point

1.0 MANAGEMENT

Prerequisite 1: Green Building Accredited Professionals

Required

The applicant should engage at least two green building council (GBCSL) accredited professionals in the team in order to Integrate of Green Building aims together with Disaster Risk Reduction (DRR) & disaster resilience mechanisms and processes throughout the design and construction phases.

Prerequisite 2: The Professional Team

Required

The professional team consisting of at least three ~~of the following~~ professionals with minimum of one professional from each category should be available to coordinate the initiative throughout the process. The team may be selected based on the intervention required for the particular context. Following professionals are identified as relevant professionals for the coordination and management of the rating system.

Category 1:

- Urban Planner
- Architect/ Urban Designer
- Ecologist/ Landscape Architect
- Sustainability Consultant
- *Disaster risk management expert*

Category 2:

- Civil Engineer
- MEP Engineer
- Building Survives Engineer

Category 3:

- Quantity Surveyor
- Financial Specialist/ Urban Economist
- Real Estate Specialist/ Valuer
- Management Specialist

A member of the professional team has disaster risk management expertise.

Prerequisite 3: Ensure Public Involvement

Required

A public consultation and participation mechanism to ensure public involvement in the process should be available. Participation of a CBO or community interest group shall be acceptable if a formal understanding of their role in the process is established and *a community embedded urban planning and designing process is in place that makes use of local, indigenous knowledge in identifying hazard prone areas, and the strengths and weaknesses of the area in terms of disaster risk and local disaster risk management strategies.*

Information and details on prone natural hazards, local risk, and risk management strategies are incorporated into public awareness programs.

Prerequisite 4: Emergency Preparedness Information and Instructions Manual

Develop an emergency preparedness information and instructions manual for apartment residents, homeowners, commercial and other buildings, including model emergency operating procedures and a building contact directory which can be used by city residents and commercial occupants in the city.
Emergency Preparedness Information and Instructions Manual should include the following sections,

- *Introduction to the manual*
- *Applicable Vulnerable hazards and scenarios*
- *Critical Operational Functions, Systems, and Supplies*
- *Roles and Responsibilities during a hazard or an emergency*
- *Coordinating/Integrating during a hazard or an emergency*
- *Evacuation plan (routes, Shelters and stakeholder involvement, etc) including evacuation of disable and people with special health needs during an emergency*
- *Building contact & safety directory including all emergency contacts*
- *Model emergency operating procedures*
- *Training and Education*
- *Recourses and references*

Credit 1.1: The Rationale

2 Points

The application for green rating shall be submitted together with a rationale of the initiative clearly identifying the approach and methodology to achieve sustainability of the subject city.

Credit 1.2: Work Plan

2 Points

The work plan to achieve the rating within a span of 02 years should be prepared with milestones established to achieve sustainability. It is recommended that the work plan is prepared considering the segments in the rating system covering all important aspects identified.

An input schedule should also be prepared identifying the inputs of the professionals in the team, together with details of community participation and stakeholder inputs supplementing the work plan with clear timeline to cover two years

Credit 1.3: Environmental Management

Encourage and recognize the adoption of a formal environmental management system in line with established guidelines during construction.

Credit 1.3.1 Involvement of an Ecologist (We already have ecologist in the list of Professionals)

Involvement of Ecologists at the design stage and obtain a report of survey ecosystems and assess the diversity, profusions and behavior of the different organisms within them relating to the project and their recommendations.

Credit 1.3.2 Environmental Management Plan (Point 1)

The contractor implements a comprehensive, project-specific environmental management plan (EMP). The contractor should prepare EMP plan before the construction and forward to the GBCSL with the initial proposal. It should include construction dust controlling system, sound controlling system, water pollution controlling in the construction stage and waste management system. *(Specific formats and necessary measuring parameters to be specified by the GBCSL).*

Credit 1.3.3 Environment Management System (Complying with ISO 14001)

The Contractor has valid ISO 14001 Environmental Management System (EMS) accreditation prior to and throughout the project.

Credit 1.3.4 Initial Environment Review (IER) and Environment Impact Assessment (EIA)

IER and EIA should be carried out to control the adverse effects and impacts imposed on environment due to new construction being carried out and to ensure that development does not increase the hazard vulnerability of communities, for example through sand mining, or destruction of mangroves.

Guidelines for Claiming Credits

The pre requisites under this segment are intended to ensure that the professional inputs are mobilized to plan and execute identified strategies and to mobilize the citizens/ communities to maintain an inclusive approach to the process while influencing them to change their attitudes to promote and commit for sustainability

The list of accredited professionals of GBCSL is available in the GBCSL website. The applicants for green rating shall identify two accredited professionals to represent the professional team appointed to plan and manage the initiative (Pre requisite 1) The professional team shall have at least three qualified professionals identified from the list given under the pre requisite 2 as appropriate to manage the initiative. As part of the pre requisite2 a justification needs to be given on the formation of the team with a team leader identified for coordination.

In order to make the process inclusive from the inception, applicant shall engage a Community Based Organization (CBO) or a community interest group to work hand in hand with the community to involve them in the process and ensure that commitment and responsibility to achieve and maintain sustainability is generated within.

The applicant should have written confirmation from the community organization clearly identifying their commitment and responsibility for the initiative (Pre requisite3).

The three pre requisites are mandatory to obtain credits.

Credits are identified to establish strategies and activities required to achieve sustainability, under management segment two credits are identified. Credit 1.1 is assigned for establishing the rationale for the initiative clearly explain the overall expectations and strategies identified to achieve sustainability to the city.

Credit 1.2 is assigned for the preparation of work plan using MS PROJECT or PRIMEVERA software. The work plan should specifically identify milestones expected to be achieved supplemented by timeline and resource allocation plan.

2.0 CITY LANDSCAPE AND SAPTAIAL STRUCTURE

Prerequisite 1: Location

Required

The city should be located on a main link road with connectivity or easily accessible through national or regional road network.

Prerequisite 2: Boundaries and Population

Required

The selected city should have a definite boundary (administrative or physical) and should have minimum residential population more than 5000 and a minimum density of 300 households per hectare

Prerequisite 3: Local Administration and availability of a Development Plan

Required

The selected city should fall within an administrative boundary of a Local Authority and commitment of the local authority to support the initiative must be obtained in the form of a council resolution. It is also required that a gazette development plan or at least a draft development plan is available for the area.

Credit 2.1: Zoning and Land use

2 Points

Credit 2.1.1: Promotion of sustainable development (1 Point)

Promotion of appropriate zoning & land use patterns to enhance sustainability.

Compact development strategies are used in land use planning. Strict standards for development, for example, a minimum number of housing units per land parcel, are in place and that limit the sprawl of smaller towns and villages, thereby reducing the population's exposure and vulnerability to natural disasters by directing growth away from known flood-risk areas, earthquake zones, landslide areas, etc.

During the site selection process, preference is given to brownfield sites. Since compact development is governed by strictly enforced ordinances/regulations, planning approval is given only after carefully considering the hazard risks in brownfield sites. Therefore, check the resilience of the brownfield lands for potential hazards before the redevelopment and take necessary strategies to Increase the resilience of the brownfield lands in the brownfield redevelopment stage.

Credit 2.1.2: Protection and preservation (1 Point)

Action taken to protect natural resources including natural habitat and protection of historical uses, a heritage buildings and monuments with special zoning regulations and land use restrictions.

Credit 2.1.3: Site Selection (1 Point)

Assess the site condition before design to evaluate sustainable options by completing and documenting site assessment on following;

- Use Hazard Maps and identify the vulnerable hazards and vulnerability level of the site for floods, landslides. Heavy winds and Tsunamis. *Hazard zoning maps are considered when zoning and layout planning is conducted. Land use restrictions are based on hazard zoning maps and disaster risk assessment data.*
- Topography - Contour mapping, unique topographic features, elevation of the land above nearby water bodies can indicate whether the land is vulnerable to floods or inundation, slope of the land to clarify slope stability risk which can result landslides.
- Hydrology - Proximity to drainage paths, waterways, water bodies, lakes, streams, shorelines, delineated wetlands, marsh-lands, coastline and initial water storage capacity of the site would suggest potential of flood hazard areas.

You can refer the following authorities to get hazard maps;

- Landslide Hazard Zonation Maps – NBRO Guidelines (https://www.nbro.gov.lk)
- Flood Hazard Maps of the River Basins - Irrigation Department (https://nsdi.gov.lk/department-irrigation)
- The Map of Wind Loading Zones Sri Lanka - NBRO Guidelines (https://www.nbro.gov.lk)
- Coastal Line Vulnerability maps for Tsunamis – Coast Conservation Department (www.coastal.gov.lk)

Credit 2.2: Access and Mobility

2 Points

Credit 2.2.1: Improving permeability within built fabric (1 Point)

Creating alternative access, create/improve alleyways, and pedestrian paths to enhance walkability.

Low impact development practices are incorporated within urban planning to improve the soil permeability so that the fragility of the natural flood defense systems is reduced.

Visually permeable emergency evacuation routes and alternative access are introduced during potential hazardous situations.

Credit 2.2.2: Encourage use of public transport (1 Point)

Promote public transport usage by ensuring reliability, improving facilities, improving accessibility to public transport network etc.

Evacuation routes are developed as a part of public transportation systems for emergency
management planning which leads to use Pedestrian Paths & Sidewalks as evacuation routes during emergencies and hazards.

Credit 2.3: Image ability

3 Points

Under image ability the rating system recognize the effort to protect and enhance the existing image and identity of the city or measures taken to generate a unique identity to the area.

Credit 2.3.1: Vistas & Areas of Scenic Beauty (1 Point)

Strategies to enjoy vistas & enhance areas of scenic beauty to promote unique character of the area

Credit 2.3.2: Land Marks (1 Point)

Promotion and development of existing or new landmarks to improve legibility of the city. In here the creation of trails, re orientation of public spaces to focus on landmarks etc. are recognized.

Credit 2.3.3: Aesthetic Control (1 Point)

The action taken to enforce aesthetic control within the city to improve image and identity of places through special design guides recognition and facilitation of aesthetic quality of the natural and built environment is marked.

Credit 2.4: Public Space Network

3 Points

Credit 2.4.1: Integration of Public Space Network (1 Point)

The spatial structuring to accommodate public space into the city fabric with inter connection, the scale and quality of spaces created and the facilitation of public activities to stimulate and sustain public space is considered here.

Public open spaces are used as safe evacuation places. For example, the open space network is used as evacuation points and the road network as evacuation rotes which *will be linked with the public open spaces for improved access in case of emergency* as a DRR passage. *Also* public opens spaces are designed with a minimum of physical development to enable their use as a place for gathering in an emergency. *Specific design features are introduced to increase the resilience for open public spaces to mitigate the effect from natural disasters, for example, barrier walls to regulate and slow down the waves from a tsunami.*

Credit 2.4.2 Aesthetic Appeal (1 Point)

The quality of public spaces with advertisement control, public signage, accommodating public art promoting vernacular architecture and adopting modern building typologies to suit the terrain and climate constraints (shading, green cover etc.) is recognized under this credit.

Credit 2.4.3: Cultural Integration (1 Point)

The approach to accommodate & facilitate all categories of public, young & old, men & women all communities irrespective of ethnicity religious beliefs etc. in public spaces respecting cultural values of particular locality and promoting communal harmony is considered under this credit.

Measures for enhancing social cohesion between deprived, marginalised, and displaced communities are included in the urban planning procedure.

Credit 2.5: Building Typology & Energy efficient and hazard resilient Architecture

3 Points

Promotion of energy efficient and hazard resilient architecture with control of heat island effects, use of ~~appropriate~~ robust and quality building materials, dependence on natural light & ventilation while introducing hazard mitigation & preparedness measures where necessary.

Credit 2.5.1: Building Typology (1 Point)

The promotion of appropriate building typology to respond to terrain, climate condition and lifestyle of the inhabitant is considered under this credit. The dependency of natural light & ventilation, use of vernacular architecture, isolation and enclosure, traditional passive strategies, use of local materials and resources are recognized here.

Disaster resilient building typologies are enforced on commercial and residential buildings of the city through building codes and planning regulations which includes architectural & design aspect which can withstand natural hazards specially floods, heavy winds or storms, landslides and tsunamis.

- Architectural aspects : Building plan, Orientation and Shape
- Design aspects : Building foundation, superstructure, roof and their combining joints or junctions (Management Commissioning)

(Refer NBRO Guidelines (https://www.nbro.gov.lk) & Guidelines for Buildings at Risk from Natural Disasters by Society of Structural Engineers Sri Lanka)

Credit 2.5.2: Control of Heat Island Effect (1 Point)

The use of building envelops to reduce emission, greenhouse effect, reflection and heat gain into the buildings (Sun protection on the facades, green roofs and walls, ventilated and automated facades), creation of appropriate building clusters are given consideration under this credit.

Compact development practices are used to minimise urban sprawl and to reduce heat created by buildings.

Walkability is improved to reduce the use of vehicles to control the urban heat in city centers caused by vehicles.

Credit 2.5.3: Energy Efficient Architecture (1 Point)

Building orientation to benefit natural light & ventilation, use of building forms to reduce thermal mass and to shade the public access during extreme weather conditions, use of appropriate materials to avoid heat gain and reduce dependency, on air-condition, use of technology to optimize energy efficiency (cogeneration. Integrated installations demotic etc.) facilitate energy efficient modes of transport bicycle parking, electric car charging, shaded connections to public transport etc. are recognized under this credit to make buildings more energy efficient.

Guidelines for Claiming Credits

The green cities initiative focus on making cities livable and enjoyable for all inhabitant while ensuring sustainability of the environment. Spatial structures in a sustainable city shall influence eliminating inequality, upholding social justice, maintaining unique identity protecting natural environment and evolving into habitats where all communities have access to basic facilities to enjoy life

Therefore the spatial structures should reflect neighborhood character and economy of scale to accommodate and sustain all communities in the city irrespective of their cast creed or religious beliefs.

In this context it is important to respond to UN SDG 11 dealing with SUSTAINABLE CITIES AND COMMUNITIES under this segment.

In this segment a special attention was given for the selection of an urban area with a potential for urban growth and need an effort by all parties to transform the area as a "GREEN CITY"

Therefore the location of the city with proper transport linkages, a city with a defined geographical area enabling management of growth and control density of the population were considered as important. It was also specified that the selected area should have an urban density as given. This minimum density was decided considering the unique urbanization pattern in the rural areas and the residential population statistics of all established cities (provincial capitals and large towns).

In the selection, it is also important that a clear administrative (Grama Niladhari Divisions) or physical boundaries are available for the growth of the city and the initiative will not lead to urban sprawl or any logistical linkups during the transformation period.

The credits under this segment are more focus on community impact on sustainability and not dependent on major planning interventions or policy initiatives. Therefore a gazette development plan covering the relevant local authority are has been made a pre requisite.

Patterns of urbanization in Sri Lanka are more related to economic infrastructure and social structures of the regions. Although there was considerable in migration towards emerging economic centers during the early post-independence era inter regional migration has significantly declined leading to cities growing at a slower rate compared to most of the neighboring countries.

Therefore it is considered that the zoning & land use control could effectively contribute to sustainable development. The impact of applicable zoning & land use parameters and promotion of development achieve sustainability will be considered under credit 2.1.1 compliance with zoning regulation and controlling natural built ratio increasing green footprint of the built-up areas may be claimed. Under access and mobility increasing permeability in the city fabric creating options of sustainable transport made (cycle paths, electric cars etc.).

Making the city walkable and pedestrian friendly improving linkages with surrounding stabilized centers are evaluated under credit 2.1.2

The strategies adopted for traffic calming, increasing pedestrian safety, providing for public car parks and optimizing the use of car parks that are dead at certain times of the day will also be considered for credit 2.1.2

The credit on image ability recognizes image and identity of the city. How legible is the city fabric for orientation. How cultural diversity is facilitated and the measures taken to make all citizens integrated into the city. Creating cultural trails, orientate activities to integrate with public spaces. Heritage management and conservation of buildings, fusion of old and new buildings, protecting vernacular architecture is considered under the credit 2.1.3

Under public space network the quality of public space, safety of public space, connectivity of public spaces are evaluated. User compatibility and protection from natural elements, providing street furniture are some aspects that will be considered under 2.1.4

The building typology is important to maintain appropriate balance between natural and built elements. It is important to have appropriate building configuration to generate the community is effectively integrated in the city fabric. Under building typology response to orientation, topography, road network & other morphological elements to achieve sustainability is considered.

When it comes to architectural aspects of the residential and commercial buildings of the city buildings, building plan and its orientation must be planned for flood prone areas, shorter side of the building shall be oriented to face the direction of the flooding and openings should be placed in line with each other on opposite walls creating a flow path for water. For heavy winds, the wind force on them is minimum where rectangular shaped structures should be planned to have their shorter sides facing the most critical wind direction also should plan to have openings on opposite walls creating a flow path allowing the wind to pass through. For land slide prone areas, it is preferable to plan the orientation of the building in a manner that the Longer side of building to be parallel to contours while maintaining a simple and symmetrical shapes such as square or rectangular shapes.

Also when it comes to design aspects, building foundation, superstructure, roof and their combining joints or junctions should be designed structurally strong to withstand the pressure from natural hazards specially floods, heavy winds or stromes, landslides and tsunamis. (NBRO Guidelines & GUIDELINES FOR BUILDINGS AT RISK FROM NATURAL DISASTERS by Society of Structural Enginners Sri Lanka)

03. PRESERVATION AND PROTECTION OF ECO SYSTEMS

Prerequisites 1: Green Cover

Required

The identified city extent should have a minimum green cover of 20% with access to public where it is possible.

The green cover shall consists of public parks, protected forests and sanctuaries, wetlands, reservations etc., but exclude impervious access roads, car parks, loading and unloading areas etc.,

Pre Requisites 2: Inventory of Native Flora and Fauna

Required

The subject city should have an inventory of native flora and fauna and a schedule of heritage buildings recognized by the local authority

Pre Requisites 3: Blue Features

Required

The water bodies, canals and all blue features within the city should be clearly documented (including mapping) and enforced with reservation for protection and maintenance.

Flood risk management strategies are incorporated to the water bodies, canals. All blue features are designed according to the local flood risk level.

Limit disruption of natural water hydrology through proper watershed management mechanisms such as reducing impervious cover, increasing on-site infiltration, and managing storm water run-off will result to reduce the risk of flooding and flash flooding. Watershed management modifies formation of floodwater which includes land use and soil conservation to minimize surface runoff, limit erosion and sediment transport by terracing and contour ploughing, reduce impervious cover and enhance on-site infiltration through vegetation cover management and afforestation.

Credit 3.1: Increase of Green Cover

3 Points

The coherent policy for increasing green cover in the city with policy implementation mechanism, monitoring & enforcement system put in place to achieve the target #

Enhancement of city's green cover would increase the impermeable surface area of the city which will result to infiltrate more storms water from surface runoff and will reduce the risk of floods and flash floods.

Credit 3.1.1: Per Capita Green Cover (1 Point)

Two points will be allocated based on created green spaces with public access. The points will be allocated for green space available and maintained per inhabitant.

There is reflection on how communities' value essential services, and how green cover can be better integrated into current and future planning processes. Stakeholders assessing the green infrastructure take into account complexity and uncertainty, and in defining the role natural systems such as forests, floodplains, and mangroves play within infrastructure systems.

Urban Green Space Per Capita	Points
12.0 sq.m (129.0 sq.ft)	1
13.50 sq.m (150.0 sq.ft)	2

Credit 3.1.2: Strategies to Increase Green Cover (1 Point)

One points is assigned for strategies to increase green cover in the city. Tree planting campaigns, protection & conservation of green cover, declaration of sanctuary areas, increasing built: natural ratio (plot cover) in built up areas.

There is consideration of green infrastructure in development, which creates new technical options for service delivery. Hybrid approaches are utilised for a combination of natural and gray infrastructure, which provides an optimum solution to shocks and improves overall resilience of the city.

There are strategies on the extent to which the service providers, policymakers, financial institutions, researchers, civil society, regulators, and communities cooperate to put green infrastructure to work.

Credit 3.2: City Landscaping

3 Points

Credit 3.2.1: Approach to City Landscape & Community Benefits (1 Point)

Integrating city landscaping for community benefits. (establishing public parks, botanical gardens etc.) to display indigenous plants and vernacular landscaping system. Creating nature parks, entertainment areas with appropriate landscaping inputs.

Credit 3.2.2: Facilitating Green Transport Network (1 Point)

Encourage green transport to minimize the emission, facilitating low emitting greener transport systems as part of landscape strategies ~~(cycle paths, shaded pedestrian pathways etc.)~~

Encourage cycling and walking through introducing bicycle parks, bicycle pathways, pedestrian pathways and walkways, etc.

Evacuation routes are developed as a part of public transportation systems for emergency management planning which leads to use these pedestrian paths bicycle pathways & sidewalks as evacuation routes during emergencies and hazards.

Credit 3.2.3: Reducing Heat Island Effect through greenery (1 Point)

Introduction of green roofs, building shading to deflect radiation, vertical greening, soft & hard landscaping, creation of landscaped open areas in between building etc. are considered in this credit.

Credit 3.3 Protection of Natural Resource Base

2 Points

Credit 3.3.1: Conservation of Natural Resource Base (1 Point)

Action taken to conserve the natural resources base, such as potable water, native flora and fauna, mineral or such other resources, bio diversity etc.

Credit 3.3.2: Enhance Natural Resource Basic (1 Point)

Strategies adopted o enhance sustainable use of local resources, action taken to reduce, re use and recycle resources and protective measures taken to ensure revitalization or replenishment of identified resources (water, local flora & fauna, adopting native and vernacular practices etc.)

Credit 3.3.3: Revitalization (POINTS..?)

Action taken to revitalize degraded areas with improving on social infrastructure introducing new economic opportunities. Encouraging and empowers local communities to participate in the process of revival, particularly environmental improvements through landscaping & reducing hard landscaping.

Urban regeneration and urban revitalisation projects should be incorporated with DRR measures. Also, post-disaster reconstruction projects are adhering to the master urban plan of the area to mitigate urban sprawl

Credit 3.3.4: Erosion and Sedimentation Control

Implement sediment and erosion control plan which also will reduce the risk of occurrence and damage due to natural hazards

- Plant trees for erosion control which have a root system effective at holding back soil as a special strategy for landslide prone areas and trees act as a barrier against heavy winds.
- Carry out terracing and contour ploughing, vegetation cover management and afforestation for watershed management where as it controls formation of floodwater which includes land use and soil conservation to minimize surface runoff, erosion and sediment transport to nearby water bodies which will again cause floods.

3.4 Climate & Hazard Resilience

3 Points

Credit 3.4.1: Adopt climate sensitive & hazard resilient landscape design (1 Point)

Implementing strategies to protect eco- sensitive landscape areas by declaring nature reserves, adopting appropriate land use strategies, use of native plant species, avoid locating development infrastructure through environmentally sensitive terrain etc., Also avoid developments in inappropriate sites to reduce the environmental impacts and to reduce the vulnerability from natural hazards. Therefore, avoid development of buildings, roads or parking areas on portions of sites that meet any one of the following criteria:

- Land that is a prime agricultural land
- Land whose elevation is lower than 1.5m above the elevation of the 100-year flood level
- Land use along the coastal belt shall comply with the guidelines of the Coast Conservation Department (www.coastal.gov.lk)
- Land which is specifically identified as habitat for any species threatened or endangered species by the Department of Wildlife Conservation – Ministry of Environment
- The land is within the specified distance of any wetland as defined by Central Environmental Authority, or as defined by local or state rule or law, or the Ramsar Convention, which is the only global environmental treaty. The most stringent condition will apply.
    - http://www.cea.lk
    - http://www.ramsar.org
    - http://dw.iwmi.org/wetland
- Land which is prior to acquisition for the project was public parkland

Strategies to integrate disaster risk reduction and climate change adaptation are incorporated within city development plans. Local development plans incorporate specific strategies to improve climate resilience.

Introduce relevant hazard mitigation & preparedness measures as specified in NBRO guideline for all buildings situated in hazard prone areas of the city.

Credit 3.4.2: Community Action to protect environmental sensitivity (1 Point)

Community action to protect and take action to mitigate damages to environmentally sensitive landscape and promote and adopt practices (awareness & readiness) to enhance fragile landscapes shall be considered here

Credit 3.4.3: Conducting public awareness program (1 Point)

Conducting awareness programs especially for school children on the impact of climate change and educating public to respond positively for climate resilience action (avoid building on eco sensitive locations, protect forest cover, protect wetlands promote biodiversity in built up areas etc.

Information and details on local risk, risk management strategies are incorporated into public awareness programs.

3.5 Development of Environmentally Degraded Areas

3 Points

Credit 3.5.1: Improve & Integrate Environmentally Degraded Areas (2 Points)

Identify environmentally degraded areas and prepare strategies to re develop and integrate such areas in to the city fabric.

Check the resilience of the environmentally degraded areas for potential hazards before the redevelopment and take necessary measures to Increase the resilience of these environmentally degraded areas in redevelopment stage.

Credit 3.5.2: Eliminate Causes (1 Point)

Action to eliminate causes that lead to environmental degradation such as poverty, high unemployment, substandard housing and building stock, locating polluting industries, poor social infrastructure, unsightly and unhygienic disposal of waste etc.

Credit 3.5.3: Revitalization (1 Point) more than allocation points

Action taken to revitalize environmentally degraded area with improvement on social infrastructure, activating economic base or introducing new economic opportunities , encouraging and empowering local committees to participate in the process of revival, particularly environmental improvements through landscaping & reducing hard landscaping.

Guidelines for Claiming Credits

All commercial & residential buildings should use relevant hazard mitigation & preparedness measures as specified in NBRO guideline. As examples for flood & landslides prone areas,

- Apply best practices in flood proofing where Constructing the Lower Levels of the building Water Tight with Wet Flood Proofing & Post-Flood Drainage systems (basement infills and flood openings to manage storm water).
- Rising the elevation of building above the Base Flood Elevation (B. F. E.) of the respective construction site and an area with a low probability of flood the space below the living area can be utilized for parking the vehicle, laundry or bathroom etc. The floor elevation shall be raised by increasing

the plinth either by building on a higher ground or or by creating an elevated ground or Construct the building on silts (The B. F. E. is the water surface level for a flood of 100 years return period.)

- Introduce flood barrier walls as a solution to the threat of flooding at ground levels in storied buildings.
- Require fire protection equipment to be raised in new construction, above the elevation of the 100-year flood level.
- Land use, required earth works, Construction of suitable earth retaining structures & application other slope stabilization techniques, designing of surface & sub-surface drainage networks along the slopes & building construction methods (terraced buildings and elevated structure on columns or raised footings supported on natural ground) can be applied for the constructions carried out in hilly and landslide prone area.

04. PROMOTING SUSTAINABILITY IN ECONOMIC DEVELOPMENT

Pre-Requisites 1: The economic base of the City

Economic diversification is facilitated through mixed developments within the city so that during a hazardous situation the risk towards income sources are spread across a range of industries.

Pre-Requisites 2: Resource base of the City

A tailored resource base is available to support disaster management plans in hazardous situations:

1. *Institutional capacity: a clear structure, role, responsibilities, and relationship between all levels of government.*
2. *Human resources: sufficient personnel, proper task delegation, and division of labour.*
3. *Policy for effective implementation: Availability of appropriate policies, rules, and regulations for making decisions, mobilising resources and engaging relevant public/private organisations.*
4. *Financial capacity: sufficient financial resources to support activities in all stages of disaster management.*
5. *Technical capacity: effective logistic management system, sufficient technology information systems, and communication networks between organizations, communities, and media representatives.*
6. *Leadership: local level leadership is built to make quick and appropriate decisions if and when needed.*

Pre Requisites 3: Land profile of the City

Land Fragmentation, Land Tenure, Build ability

Hazard risk in land profiles are incorporated into land pricing

Credit 4.1: Sustainability as a key economic driver

2 Points

Business continuity plans that address disaster risk are available for the corporate citizens / businesses in the city at all scales.

Credit 4.2: Creating a Circular Economy

2 Points

Circular economic conditions have been created within the city limits to reduce volatility and greater security of supply during a hazardous situation. Decentralized operators are promoted to provide alternative material sources.

Credit 4.3: Balancing Corporate Strategy & Corporate Social Responsibility

2 Points

Potential disaster risk transfer mechanisms are available for the corporate citizens / businesses of the cities.

Inputs for investing in disaster resilience by the local businesses and corporate citizens as a part of their corporate social responsibility are recognized and supported by the local authorities.

Credit 4.4: Promotion of Sustainable Products & Services

2 Points

Investments in structural and non-structural disaster resilience measures are promoted through the provision of financial incentives such as tax rebates, grants, or a reduction in insurance premiums.

5.0 PROVISION OF SUSTAINABLE INFRASTRUCTURE

Prerequisite 1: Energy & safety Audits

Adaptive technologies that do not fail during disasters are used to ensure that infrastructure is resilient.

Undertake a safety audit of major infrastructure systems such as transportation infrastructure, critical infrastructure including hospitals and schools and multi-storied commercial and residential buildings and the emergency backup systems of those infrastructure systems.

Credit 5.1 City & Energy

10 Points

Credit 5.1.1: Encourage to Use of Renewable Energy

Smart grids are incorporated to improve energy, reducing accidents and infrastructure failures during a disaster.

Supply renewable sources of energy to improve resilience and efficiently mitigate in disaster situations specially to be used during blackouts and emergency blackouts through solar or/and other renewable energy sources.

Credit 5.1.2: Greenhouse Gas Emission Management

Credit 5.1.3: Emergency Energy & Power Requirement

All buildings and infrastructure facilities (specially in hazard prone areas) should install reliable backup & emergency power sources and communication systems including Backup Fire & Life Safety Communication systems.

Choose reliable backup & emergency power sources such as Generators, back up batteries, Cogeneration & Solar during Blackouts together with a fire protection & detection system.

Keep Commercial & Residential Building Stairwells, Hallways and emergency exits lit during blackouts due to natural hazard using generators or other reliable energy sources.

All large buildings in flood zones should consider having a backup wireless fire communication system, and new large critical buildings must have backup phone and data connections. Mandate the use of storage batteries with a life of at least eight hours to serve buildings' fire and life safety communication systems.

Credit 5.2 City & Water

8 Points

Credit 5.2.1: Water Conservation

Emergency shutoff valves are installed at the storage points to avoid water wastage.

Credit 5.2.2: Innovative & Emergency Transmission of Water

Installation of uninterruptible power supply at pumping stations to prevent service disruption during blackouts occurred in emergencies and hazards.

Credit 5.2.3: Water System Performance, Rainwater Harvesting &Storm water Management

Drainage capacity has been designed to meet future threats. Rainwater management systems take account of future climate projections and rain fall patterns.

Installation of storm water collection systems integrated to rain water harvesting tanks or storages should be designed and installed to handle greater quantity, intensity and precipitation especially in flood prone areas and other areas as well within the transportation infrastructure (road pavements), other infrastructure facilities, commercial and residential buildings. Then these storm water collection tanks can be connected and installed as underground mini reservoirs depending on the rainfall data of the area which can reduce greater amount of flood hazards in urban areas while using the collected rainwater for irrigation purposes and toilet flushing of infrastructure facilities.

The reliance on public water and wastewater systems are reduced in case of an emergency situation such that redundant emergency networks of water supply wastewater treatment are made available by creating secondary facilities, redundant transmission-distribution pipelines or multiple water storage facilities.

Credit 5.2.4: Wastewater Management &Wastewater Treatment
Increase drainage capacity to meet future threats.

Credit 5.2.5: Re-use treated waste water

5.3 City Traffic & Transport Network

10 Points

Credit 5.3.1: Transport policy initiatives to improve performance

Facilitating multi- modal integration

Maintaining quality standards of transport infrastructure (roads, bridges, pedestrian crossings, disability access etc.)

Emergency preparedness and post disaster instructions are displayed in all Transportation
infrastructure facilities (transit shelters, bus and train terminals, bicycle parks and public transport vehicles etc.) for the awareness of occupants and passengers.
Smart transportation networking is adopted for early warning, emergency management and to direct the community for evacuation routes.

Credit 5.3.2: Actions taken to increase dependency on public transport and non-motorized transport

Provide special transport facilities such as school busses, shuttle services, and park and ride facilities, bus stops, to encourage use of public transport.

All transportation infrastructure facilities (transit shelters, bus and train terminals, bicycle parks and public transport vehicles etc.) should install reliable backup & emergency power sources and communication systems including Backup Fire & Life Safety Communication systems to be used during a hazard or an emergency situation. Choose reliable backup & emergency power sources such as Generators, back up batteries, and Renewable sources of energy such as Cogeneration & Solar during Blackouts together with a fire protection & detection system to improve resilience and efficiently mitigate in disaster situations. All transportation infrastructure facilities in flood zones should consider having a backup wireless fire communication system, and all transportation infrastructure facilities must have backup phone and data connections. Mandate the use of storage batteries with a life of at least eight hours to serve infrastructures' fire and life safety communication systems.

Keep all transportation infrastructure facilities' and services' (transit shelters, bus and train
terminals, bicycle parks, evacuation routes and public transport vehicles etc.) stairwells, hallways and emergency exits Lit during blackouts due to natural hazards using generators or other reliable energy sources such as solar or/and other renewable energy sources and provide portable emergency lighting by providing the occupants with hand-held lighting equivalent to 6-8 LED diodes in brightness for groups of occupants

Emergency pathways and evacuation routes along the sidewalks should always have a backup power system to light the lighting systems along the evacuation routes during an emergency situation.

Credit 5.3.3: Parking Policy and Traffic Management

Provision of public car parks and control road side parking while avoiding impermeable parking areas as much as possible to increase the amount and rate of storm water infiltration and thereby reduce the risk of flooding.

Develop standard operating procedures for traffic management during early warning and
emergency situations along with the regular traffic management plan.

Develop a traffic signal system to be operated during early warning and emergency situations
along with the regular traffic signal system.

Credit 5.3.4: Improve road safety and safety of pedestrians and cyclists

Introducing traffic calming measures including emergency and hazard situations as well.

Improving pedestrian crossing designs (Locations, Signage, Illumination, Safety measures, etc.)

Introducing under passes, overhead bridges with disability access for pedestrian crossings

Introducing covered pedestrian paths and elevated links to avoid road level crossings

Credit 5.3.5: Encouraging Mixed Use & Transit Oriented Development (TOD)

Protection of transit systems from hazards by providing and maintaining hazard protection systems for short-term and long-term resiliency such as protecting below ground system vents and entrances from flooding, planning systems for 100 -year floods (ReLi 500) and providing of distributed generation power sources.

06. RESOURCE MANAGEMENT

Prerequisite 1: Waste Profile

Required

Prerequisite 2: Waste Management Plan

Required

Credit 6.1: Waste Management

4 Points

Credit 6.1.1: Management of Liquid, Gaseous & Solid Waste (including e waste & construction waste) (2 Points)

Take appropriate measures to safeguard hazardous waste including toxic waste collected and stored in all the buildings and infrastructure systems of flood prone zones by storing them in a flood proof area or above the elevation of the 50-year flood level which water can't be reached.

Credit 6.1.2: Strategies adopted for waste management (Refuse, Reduce, Reuse, Recycle, Recover) (2 Points)

Credit 6.2: Pollution Management

4 Points

Credit 6.2.1: Management of Noise, Odour & Visual Pollution (2 Points)

Credit 6.2.2: Management of Air Pollution (1 Point)

Credit 6.2.3: Management of Water Pollution (1 Point)

6.3 Construction Material Profile

Can include hazard resilient materials here

6.3.1 Building and Resource Reuse & Recycled Content/Materials

6.3.2 Local/Regional Materials, Certified Wood and Other Green Certified Building Materials

6.3.3 Rapidly Renewable Materials

6.3.4 Global Warming Potential (GWP) of Buildings

Quantify the Global Warming Potential of a building to reduce the environmental impact due to buildings.

07. PROVISION OF SOCIAL INFRASTRUCTURE

Prerequisite 1: Demographic assessment

Required

Demographic assessment covering growth rate, life expectancy, age pyramid, gender and ethnic profile

Credit 7.1: Access to Education

2 Points

Credit 7.2: Availability of healthcare facilities

2 Points

08. PROVISION OF CULTURAL INTEGRATION

Prerequisite 1: Marked City Plan

Heritage projects, places of scenic beauty, historical, cultural and religious places should be mapped on the city plan.

Systems are in place by means of responsiveness to culture to better understand the community needs and promote a culture of prevention with a strong community involvement. This helps to avoid disconnection, disillusionment, distress and dysfunction. Cultural integrated processes are developed through participatory processes and emphasise the importance of tailoring them to the needs of users, including social and cultural requirements of the city.

Credit 8.1: Ensuring equality and social justice to all citizens

2 Points

A human rights-based approach is adopted, promoting and protecting all human rights, including ensuring equality (when each person is seen as equal in the eyes of the law with no discrimination based on their gender, race, religion, or sexuality, and social justice) to all citizens. Each person can exercise their rights within the society with the promotion of social justice, which ensures that everyone has physical security, education, healthcare, and employment.

Credit 8.2: Cultural integration of communities

2 Points

Credit 8.3: Heritage Management & Place Making

2 Points

There is a place and people-led approach towards urban heritage and place-making. Urban designs respond to urban landscapes with historical contexts, while actively engaging with the place-making process, where the old and new components of a city merge to create new meanings for users, enhancing the place identity, and spatial and historic connectivity of the urban landscape

09. GLOBAL IMPACT ON LOCAL INITIATIVES

Credit 9.1: Impact of environmental improvements

2 Points

Credit 9.2: Delivering UN sustainability goals

2 Points

Development supports the UN Sustainable Development Goal 11 targets on making cities safe, resilient and sustainable:

- *Action is taken to significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.*

- *Integrated policies and plans are adopted and implemented towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels.*

Credit 9.3: Recognition of accredited green initiatives (buildings, products, services etc.)

2 Points

10. INNOVATION IN SUSTAINABILITY & RESILIENCE

Credit 10.1: Adoption of New technology for sustainability

3 Points

Credit 10.2: Developing business models for clean tech economy

3 Points

Credit 10.3: Innovative climate change & hazard management

2 Points

Climate change management is seen as an integrated approach to disaster risk reduction. Therefore, measures are taken to avoid duplication of resources used for separate climate change adaption and disaster risk reduction initiatives.

Introduce flood, earthquake and landslide warning systems and sensors in all major infrastructure facilities and services (multi stories residential and comercial buildings, ctitical infrastructures such as hospitals and schools) to detect the respective hazards and disseminate early warning alerts.

Maintain an Emergency & First aid Kit to be stored in first floor of buildings and infrastructure facilities to be used during an emergency. Emergency & First aid kit may contain items such as, water bottle, flashlight (crank or battery-powered and Replace batteries once a year.), emergency operation manual with emergency contacts, a whistle, candles, a match box, and first aid kit, etc.

Credit 10.4: Innovative intervention for attitude change on sustainable environment

2 Points

Coherent approaches are in place to integrate disaster resilience for sustainable development. For example, there is adequate training for built environment professionals to ensure they are aware that sustainability encompasses many dimensions, including resilience, as well as the environment and physical development.

Credit 10.5: To provide safety for buildings and infrastructure occupants from the hazards caused due to lightening

Design the lightening protection plan and system to be used and installed in all transportation infrastructure facilities such as transit shelters, bus and train terminals, and bicycle parks, etc.

11. MANAGEMENT & MONITORING OF THE TRANSFORMATION OF CITY PROFILE

Prerequisite 1: City Profile

Required

A format of the city profile identifying key features that will be changed or improved in order to achieve sustainability of the city must be prepared and submitted together with the application for accreditation. (GBCSL shall advise the applicant to reformat the profile and update information whenever an evaluation/review is undertaken.)

Prerequisite 2: A Management Cell

Required

A management cell shall be established by the applicant to liaise with the GBCSl to process the application. (A green accredited professional in the team, shall be part and parcel of the management cell)

Credit 11.1: Positive changes in the City Transformation

1 Point

Cities' development trajectories are the result of local constellations – prevailing political powers, regulations, finance and many other factors that shape cities into complex, hybridized and disaster resilient systems. Understanding differences as well as shared experiences is in place as the first step towards finding an entry point for sustainable transformation.

Credit 11.2: Improving the Environmental Performance

1 Point

Solutions are developed to address current and future environmental risks such as maintenance of green and blue infrastructure through nature-based solutions or protection of the ecosystems. The city's contingency plan for flooding is developed in coordination with stakeholders from the municipality and civil society. The city places great emphasis on disaster risk reduction and climate change adaptation measures, and environmental management.

Credit 11.3: Changing Attitudes towards green action

1 Point

In assessing the attitudes towards green impact of ecosystems, as critical infrastructure, service providers, policymakers, financial institutions, researchers, civil society, regulators, and communities cooperate to put green action to work. There is clarity to determine which green action and ecosystems are to be considered. The city is empowered to develop and implement a strategic environmental plan in line with local policies and agendas and demonstrates performance in several areas such as biodiversity, air quality, environmental education, and water management.

Credit 11.4: Management & Monitoring mechanism

1 Point

Regular monitoring and follow-ups are in place to ensure compliance with the set objectives and targets. Specially, carryout relevant structural health monitoring checks of the building structures in specific predetermined periodic time intervals (usually annually), depending on the location of the building, under the monitoring and targeting the resilience of the buildings to withstand against the natural and other hazards.
These encompass aspects related to quality, cost and time, and disaster resilience properties and provide the opportunity to understand progress and, consequently, to take corrective actions where necessary. Monitoring and evaluation is also used to evaluate the success of the city resilience building efforts through performance indicators established within the city action plan and to measure their impacts. There are monitoring and evaluation tools to measure impact and success in place including a local level reporting system to convey the results and best practices and to identify corrective actions and revise the action plan based on feedback.

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INCORPORATION OF DISASTER RISK REDUCTION MECHANISMS FOR FLOOD HAZARDS INTO THE GREENSL® RATING SYSTEM FOR BUILT ENVIRONMENT IN SRI LANKA

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Abstract: Global human population continues to boom which consequently necessitates the provision for more buildings. Predominantly in developing countries, these buildings, built to accommodate the influx of more people comply with local and national building laws and regulations which have been outdated and do not resist to natural hazards and rapidly changing natural global trends such as climate change and global warming, etc. Disaster risk in Sri Lanka is increasing mainly due to unplanned urbanization, outdated and poor quality buildings and infrastructure, and the impacts of climate change. This has exposed the community and their economic assets vulnerable to natural hazards such as floods, cyclones, landslides, droughts, coastal erosion and tsunami. Out of those, floods are considered to be the most frequent as well as which destroyed and damaged the highest number of buildings during the period of 1965 to 2019. As more anthropogenic natural hazards like floods pile up, it is essential that developments, specially buildings which are community shelters, to be disaster resilient and be designed to withstand strains and pressure which will be imposed by future trends. Therefore, sustainable hazard mitigation measures are required to develop a safe, economically feasible, environment-friendly and socially approved growth in Sri Lanka. Although Green Building Council of Sri Lanka (GBCSL) has promoted sustainability and resilience, specifically through reducing resource usage and energy consumption, it has not properly recognized the need of incorporating Disaster Risk Reduction (DRR) mechanisms to withstand against the natural hazards in their GREENSL® Rating System for Built Environment. This research paper is focused on identification of structural and non-structural DRR mechanisms for flood hazards which can be incorporated into the GREENSL® Rating System for Built Environment through refinements to the sub-categories under main 8 categories.

Keywords: Disaster Risk Reduction; Flood Hazard; Disaster Resilient Buildings; Climate Change; Sustainable Buildings

1. Introduction

According to World Health Organization (WHO), every year natural disasters kill around 90 000 people and affect close to 160 million people worldwide. Natural disasters include earthquakes, tsunamis, volcanic eruptions, landslides, hurricanes, floods, wildfires, heat waves and droughts. They have an immediate impact on human lives and often result in the destruction of the physical, biological and social environment of the affected people, thereby having a longer-term impact on their health, well-being and survival. Also according to the report ‘Economic losses, Poverty and Disaster - 1998 and 2017’, published by United Nations system for Disaster Risk Reduction (UNISDR), during the period of 1998 and 2017, climate-related and geophysical disasters have killed 1.3 million people and left a further 4.4 billion injured, homeless, displaced or in need of emergency assistance. While the majority of fatalities were damaged and destroyed due to geophysical events, 91% of all disasters were caused by floods, storms, droughts, heatwaves and other extreme weather events. In 1998-2017, disaster-hit countries experienced direct economic losses valued at US$ 2,908 billion, of which climate-related disasters caused US$ 2,245 billion or 77% of the total. This is up from 68% (US$ 895 billion) of losses (US$ 1,313 billion) reported between 1978 and 1997. Overall, reported losses from extreme weather events rose by 151% between these two 20-year periods.

When it comes to Sri Lankan context, Sri Lanka was considered as the 2nd most affected country from extreme weather events during 2018 (Germanwatch Global climate index). Sri Lanka is considered as a tropical country due to its placement near the equator which experiences high temperatures and frequent rainfalls almost through out the year. Wet zone of Sri Lanka receives over 5000 mm of annual rainfall as the country is located in south west monsoon region whereas northern and eastern lands of the island are usually identified as dry zones due to the mounting barrier of the central highland. Within this background, disasters with hydro-meteorological origin are more common and act as annual events in the country. River floods, urban floods, landslides, cyclones, wildfires are considered as primary hazards with high risk and coastal erosion, tsunami and droughts with medium risk (PreventionWeb, Sri Lanka Disaster & Risk Profile). Table 1 below shows Summary of deaths, houses destroyed and damaged, number of affected victims, and losses from main disasters occurred in Sri Lanka during the period of 1965 to 2019. The most common natural hazards in Sri Lanka include localized and seasonal floods and associated landslides while less frequent but more severe hazards include cyclones, droughts, and tsunamis (PreventionWeb, Sri Lanka Disaster & Risk Profile). Also Sri Lanka was among one of the worst hit countries by the 2004 Indian Ocean Tsunami. According to World Bank estimates, the country’s average annual losses are $380 million which is 3% of total government expenditure. Figure 1 below shows the breakdown of nationally reported economic losses due to main natural hazards occurred during 1990 to 2014 in Sri Lanka. Sri Lanka’s flood risk profile is rising day by day. In the Colombo Metropolitan Region, economic growth and changes in land use are exacerbating flood risk. In 2010, heavy rainfall and flooding affected about 50 percent of the private sector. In May 2016, Tropical Storm Roanu caused flooding and landslides in 22 out of 25 districts. Over 90 people were killed and damages and losses, per the preliminary post-disaster needs assessment, exceed $570 million. Climate change is expected to increase the frequency and impact of hydro-meteorological hazards. Major flooding in 2010, 2011, 2014, and 2016 exemplifies a 20-year trend (GFDRR, Sri Lanka). According to the records of Disaster Management Center (DMC) of Sri Lanka and UNISDR, floods are considered to be the most frequent, highest number of buildings during the period of 1965 to 2019 in Sri Lanka. Therefore, the focus of this research paper is into the flood hazards of Sri Lanka.

Flood can be defined as the condition in which the land is submerged in water which is normally used to be dry. It can be attributed to an unusual high stage of a river or other water bodies like lakes, oceans etc. during which the water spills over the bank and spread to the adjoining land. The low-lying area adjacent to a river bank is called flood plain, which is formed mainly of the sediments of river and consists of a very fertile soil. For a flat or low-lying land with infiltration or runoff rate lesser than the rate of precipitation, water can accumulate resulting in a flood situation (Khan, M.K. and Ahmad, S., 2017). Due to different natural phenomena like rainfall lasting for a longer period of time, monsoon seasonal rains or tropical cyclones, floods occur in rivers or other drainage systems. In coastal areas, when the water level is high due to some storm and its combines with the natural high tide the water spills over to the adjoining areas causing a flood. In urban areas due to improper drainage system sometimes due to high precipitation water can accumulate on the streets and maybe sometimes comes back into the building through sewers pipes when rainfall is higher than the drainage capacity. Rising rate of population and consequent urbanization leads to deforestation and a high percentage of the paved surface which blocks the infiltration of water in case of precipitation. Lesser infiltration leads to high runoff resulting in rapid and increased hydrographic peak which creates floods (Khan, M.K. and Ahmad, S., 2017). This increasing trend of flood hazards and disaster losses caused to the built environment are mainly due in part to the unprecedented rate of urban growth, increasing dependence on complex infrastructure, unplanned urbanization, outdated and poor quality buildings and infrastructure, and the impacts of climate change that are increasing exposure to anthropogenic and natural hazards (Amarathunga *et al.*, 2017).

Table 1: Summary of Deaths, Houses Destroyed and Damaged, Affected Victims and Local Losses from Main Disasters Occurred in Sri Lanka (1965 - 2019)

Hazard / Disasateer	Number of Deaths	Houses Destroyed	Houses Damaged	Number of Affected Victims	Local Losses ($)
ANIMAL ATTACK	1,002	197	7,715	80,207	0
Coastline & coastal erosion	0	153	437	4,137	0
Collapse of Building	15	0	1	12	0
Collapse of Gabage Fill	32	60	22	1,782	0
CYCLONE	846	18,208	111,565	1,375,005	0
CYCLONE & FLOOD	9	13,178	37,371	319,128	0
DROUGHT	0	0	0	20,725,949	0
EARTH SLIP	10	56	168	3,043	0
EPIDEMIC	368	0	0	572,644	0
EXPLOSION	1	161	346	7,952	0
FIRE	108	2,078	1,043	16,489	7,700,000
FLASH FLOOD	6	72	684	8,812	0
FLOOD	707	55,003	186,548	15,068,593	378,500
FOREST FIRE	1	16	19	198	0
HEAVY RAINS	37	689	7,583	780,213	0
LANDSLIDE	1,077	2,900	12,026	291,964	1,038,000
LIGHTNING	549	37	595	4,014	0
STRONG WIND	211	7,693	104,548	731,571	1,077,900
TORNADO	0	58	277	910	0
TSUNAMI	30,959	57,085	48,069	970,705	16,130,000
URBAN FLOOD	0	0	0	155	0

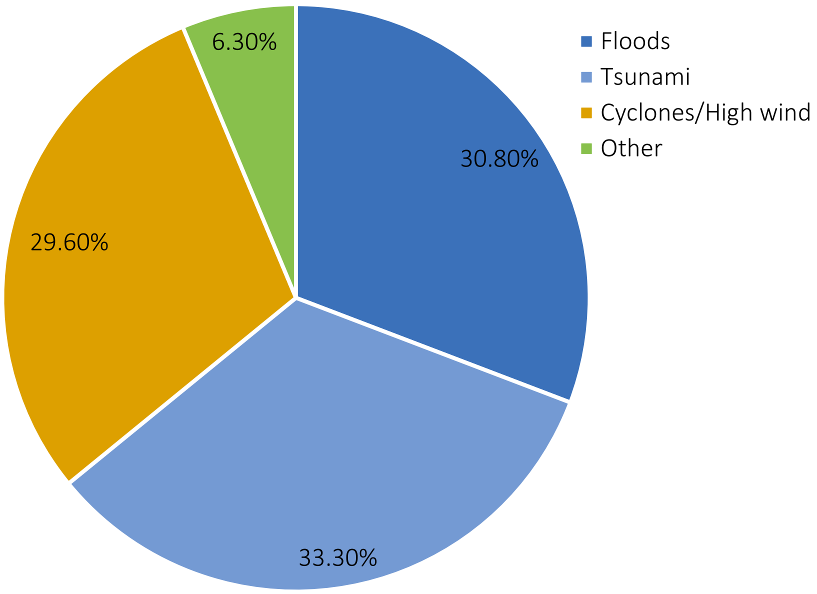

Figure 1 : Nationally Reported Economic Losses (1990-2014)

Also, a study conducted by the Asian Institute of Technology in 2012 has investigated the adoption of disaster resilience measures for wind, rain and flood and landslides in the national building codes. This highlights that landslide resistance and flood situations are not considered in the Sri Lankan building codes and consideration of wind effects are also voluntary. A detailed, comprehensive disaster resilient building code could not be found in Sri Lanka. A further study conducted in Sri Lanka during 2014 revealed a lack of adequate regulatory frameworks, unplanned urbanization and city development, outdated building stock and infrastructure which are not a safe condition, unauthorised developments, inappropriate institutional arrangements, inadequate capacities at the local level, a lack of funding, an inadequacy of qualified human resources, and corruption and unlawful activities (Malalgoda, C. *et al.*, 2014). These factors will undermine efforts to increase disaster resilience in the built environment. Built environment consists of infrastructure such as roads, railways, schools, hospitals, phone lines, treatment plants and power generation plants and buildings which includes single storied to high rise commercial and residential shelters. The focus of this research paper is about the buildings in the built environment but not about its infrastructure component. Although GBCSL has promoted sustainability and resilience, specifically through reducing resource usage and energy consumption in buildings, it has not properly recognized the need of incorporating DRR mechanisms to withstand against the natural hazards in their GREENSL® Rating System for Built Environment. Although GBCSL has promoted the green buildings among the Sri Lankan community, the sustainability of those buildings to withstand against strains and pressure which will be imposed by increasing trends of hazards like floods are questionable. Even though the buildings constructed are platinum rated green buildings which have been applied with many greener and sustainable concepts, they are not sustainable if they can not resistant which is simple can be damaged or destroyed against the natural hazards. Therefore incorporation of DRR and disaster resilient mechanisms in to the community shelters which are buildings becomes very important and vital for a sustainable built environment. The DRR mechanisms for flood preparation and mitigation can be categorized into structural (hard) and non-structural (soft) measures. Efficient flood fore-casting warning systems, following laws and regulations and awareness raising etc come into nonstructural approach whereas small to large scale constructional components added to the buildings to mitigate flood risks and damages are considered to be structural approaches. This research paper is focused on identification of structural and non-structural DRR mechanisms for flood hazards which can be incorporated into the GREENSL® Rating System for Built Environment through refinements to the sub-categories under main 8 categories. Therefore, globally used structural and non-structural measures for flood resistant buildings, applicable to Sri Lankan context are discussed in the following sections of the paper.

2.0 **Structural (Hard) DRR Mechanisms for Flood Preparation and Mitigation**

Under this section, the structural measures which have been taken and applied in world wide for flood mitigation and protection will be discussed. When it comes to hard DRR mechanisms, flood performance of buildings can be categorized as, structural performance, material performance and impacts of contamination as well. Around the world, there are many structural mechanisms and approaches are proposed for making the buildings more capable to resist floods.

2.1 Planning Phase of Building Orientation and Placement of Openings

Identify the flood zone and the maximum flood level recorded in the selected location or site, using available sources or by contacting relevant authorities. i.e. Irrigation Department. Then the direction of the flooding is to be identified properly. The it comes to the building plan and its orientation, shorter side of the building shall be oriented to face the direction of the flooding as shown in Figure 2 below. Also openings should be placed in line with each other on opposite walls creating a flow path for water as shown in Figure 3 below.

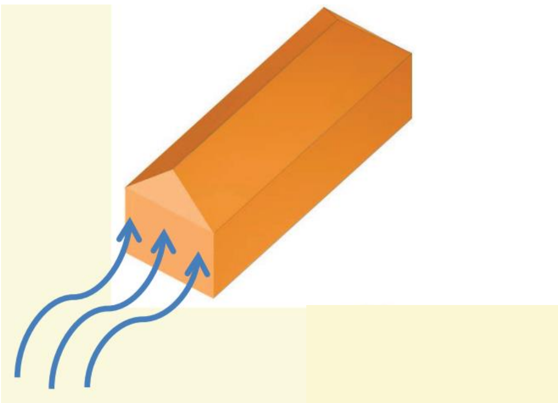

Figure 2: Shorter Side of the Building is Oriented to Face the Direction of Flooding

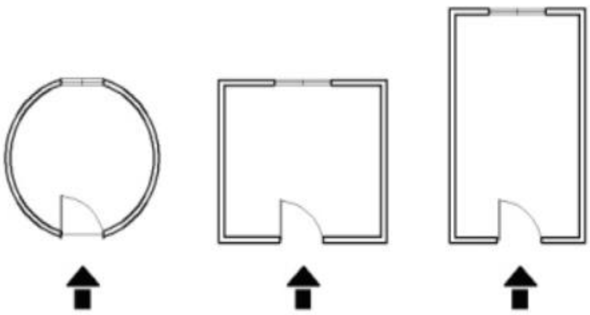

Figure 3: Placement of Openings in the Buildings, creating a flow path for water

2.2 Foundations of the Flood Resistant Buildings

Concrete slabs and foundations are the most suitable foundation type to be used to withstand the natural hazards and pile foundations can be used where problematic soil conditions exist. Buildings should be located via stable foundations on soil strata having no susceptibility for liquefaction due to flooding. Depth of foundation shall be increased as follows;

- The column footings shall be lowered minimum 1.0m below finished grade.
- Wall footings shall be lowered minimum 0.6m below grade.

Also flood barrier walls can be designed and introduced as a solution to the threat of flooding at ground levels in storied buildings.

2.3 Rising the Elevation of the Buildings

Mainly, there are two types of elevated buildings are available as below.

The floor elevation shall be raised by increasing the plinth either by building on a higher ground as in Figure 4 below or by creating an elevated ground as shown in Figure 5 below. The plinth height shall be minimum 150mm above the highest recorded flood level in the region.

Construct the building on silts where the silts shall be raised up to minimum 150 mm above highest recorded flood level in the region and the maximum unsupported height of silts shall not exceed 3m. Otherwise an intermediate tie beam shall be provided as shown in Figure 6 below.

Here in both options, the elevation of living area is raised above the Base Flood Elevation (B. F. E.) of the respective construction site. The house is raised on some supports which should be sufficiently strong enough to bear the load of the structure and forces acting by the flood water and have ample space for the passage of flow in case of flood. For an area with a low probability of flood the space below the living area can be utilized for parking the vehicle, laundry or bathroom etc. The B. F. E. is the water surface level for a flood of 100 years return period. There are many methods available for estimation of flood; for some sites with lesser available data or for sites with no data available at all, regional flood frequency analysis can be used (Alam et al. 2015, 2016).

Existing buildings which can not be elevated also should be retrofitted and improved to be disaster resilient in a way that the basement infills and flood openings can help manage storm water. Converting the lowest floor to nonessential uses like a garage can reduce the flooding impact to living areas.

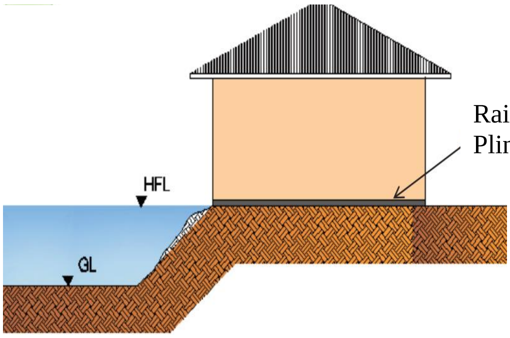

Figure 4: Plinth Level Raised by Building on Higher Ground

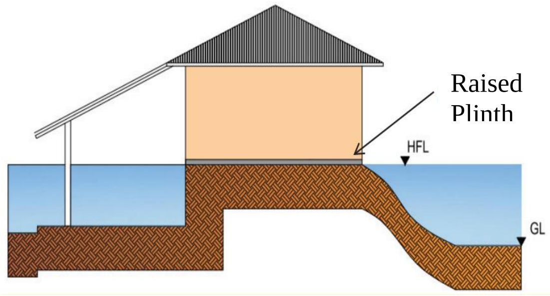

Figure 5: Plinth Level Raised by Creating an Elevated Ground

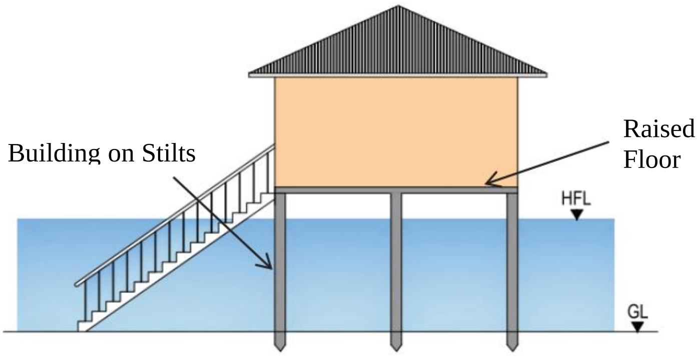

Figure 6: Plinth Level Raised by Building on Silts

2.4 Superstructure of the Buildings

Cross walls are the main superstructure type used in the flood resistant buildings as the criss walls can be utilized to strengthen walls against flow of flood water. Figure 7 below indicates the placement of cross walls inside the building. Also at least 4 reinforced concrete columns at the four corners of the building are required for the strenmhinng of the building. For wall lengths exceeding 6 m, an additional intermediate column along that wall should be introduced. These columns are essential for buildings in the coastal zone subject to flooding. Walls should be made as heavy as possible; if hollow blocks are used they should be at least 200 mm thick, and if 100 mm thick walls are used, they should be of solid block work or brickwork. Such walls would provide a basic level of thermal insulation and rain protection too. The sizes of openings on walls should be such that the aggregate width of openings on any wall do not exceed 50% of the width of that wall.

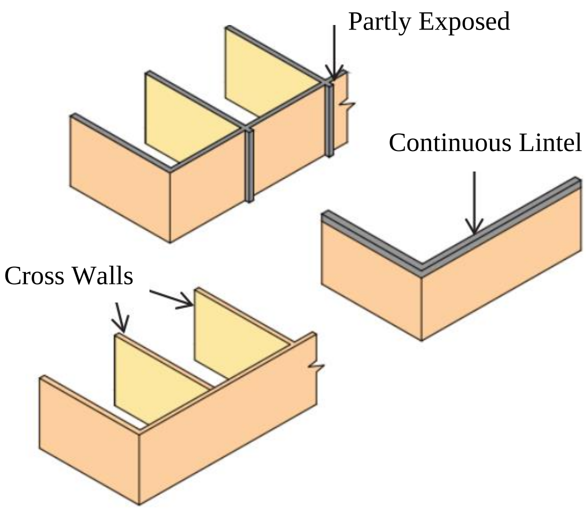

Figure 7: Cross Walls

2.5 AMPHIBIOUS Buildings

Amphibious buildings can be used in both land and water and they are made in such a way that they are free to float on the flood water and rose with the water level and comes back to their or original initial position as the flow recedes. Amphibious buildings are mainly constructed for residential purposes as houses around the world in areas such as Maasbommel, Netherlands, and at Raccourci Old River, Louisiana, New Orleans and Bangladesh due to very frequent floods they face. There are major two types of amphibious houses can be found as, boat type and lift type.

2.5.1 Boat Type AMPHIBIOUS Buildings

This type of floating building is free to move in both vertical and horizontal directions. The floor of the building is designed to be water tight so the water does not enter from the base to the floor area. The building has an anchor system to stop the house to dislocate from its original position with the flow of water.

2.5.2 Lift Type AMPHIBIOUS Buildings

When it comes to lift type amphibious buildings, these buildings are free to move only in vertical direction in a controlled way along with the rising water level in a flood situation. The building is restrained to move in horizontal direction by guiding columns at the corners. The building remains on ground surface until the flood water starts lifting it up by buoyant forces. Both type of amphibious buildings can be provided with a suitable base to be supported on and to provide sufficient buoyant forces required to initialize the movement. The foundation used in these houses can be termed as buoyant foundation. Underside of the house buoyancy blocks are provided. Buoyancy blocks lift the house in case of flood and can be made of recycled, recapped plastic bottles as well.

2.6 Flood Proof Construction Materials

Building with robust materials which have a high versatility and strength, wind and water resistance, tsunami resistance, fire resistance, energy efficiency and durability. Concrete building systems are especially suited to provide resistance to natural hazards. Concrete doesn't rot or rust even if it is subject to flooding. Concrete has the necessary hardness and mass to resist the high winds and flying debris of high winds. Concrete is fire resistant and non-flammable, which means it can contain fires and will not contribute to the spreading of fire. Reinforced concrete framing systems can be designed to resist the most severe earthquakes without collapse. Therefore, concrete structures are suitable and resist against many natural hazards including floods. Stone, brick, concrete, decay-resistant wood, and water-resistant, fibre-reinforced gypsum sheathing resist flood damage better than materials like plywood, particle board, linoleum, vinyl, carpeting, traditional gypsum, and plaster. Internal walls should be water resilient to withstand floods. For that, materials should be used which will allow fast recovery such as concrete block partitions, lime plaster or magnesium oxide board as finishing skirting is sealed with an internal cavity membrane.

Also, the materials used should be of good quality too, especially since excessive loads may have to be resisted. For binding mortar, the mix proportions should not be leaner than 1:6 cement:sand. For making cement blocks, the proportions should be 1:10 with cement and sand (or quarry dust); it can be made 1:7:10 using cement, sand and 6-8mm aggregate chips. Blocks should ideally not be used until least 1 month (or even 2 months) after casting, so that most of the shrinkage is over before the block is placed in the wall. For concrete, the quality should be at least grade 20, which can be achieved by using a 1:2:4 mix of cement, sand and coarse aggregate.

2.7 Wall to Floor Junction in a Building

Wall to floor junction is considered to be one of the main component which needs to be designed against floods as it is a major point which water leaks inside the building. There are two options available. Option 1 is, designing of a primary and a secondary layer of waterproofing which includes water tanking below slab to resist water pressure (primary layer) and a cavity drainage for water collection after flood (secondary layer). Second option is utilizing a waterproof concrete again with a primary and secondary layers of waterproofing where primary layer is consist of a concrete slab and wall with water resistant additive and the secondary layer is with a cavity drainage for water collection and removal following a flood.

2.8 Wet Flood Proofing Technique

Wet flood proofing involves the controlled and safe passage of flood water through the lower levels of the building. The building is designed to resist water up to 600mm in depth after which water is allowed to enter into the property to reduce pressure on the structure. The sewers and water system should be above the water level or should be sealed when the water rises above them to avoid any health hazards. Also sewage system can be designed with a non-return valve while drainage pipes are sealed through the "flood proof layer" , covered and locked in concrete to resist lower ground water pressure and to prevent damages from floods. Inspection chambers are fitted with anti-lift lid. All service entry points should be sealed or raised where possible and all electrics appliances and outlets should also be at higher levels above the design flood level. Kitchen units below flood level should be of waterproof materials (plastic or stainless steel hardware)while kitchen unit doors and drawers should also be sealed. The inlets points should be opened well before any pileup of water to avoid pressure at the structure. Also fire protection equipment should be raised in new construction, above the flood level. Automatic opening window panels (flood inlets) are triggered by localized sensors to allow a controlled inundation of flood water into the property.

2.9 Building the Lower Levels Water Tight

The walls and openings of the lower levels are sealed to stop the water from penetrating the building. The sealing should be sufficiently strong to bear the forces in the flood conditions acting in the form of lateral forces and uplift thrust of the flood water. The building should be designed by taking all these forces in consideration. Enclosures, sealants, membranes and coatings can be used as main construction materials to make the lower levels water tight. Flood resistant doors should be installed to protect against water entry.

2.9 Post-Flood Drainage Systems

Channels, pipes and drains are built into the floor to drain off the water after a flood. Drain connections into man hole are fitted with non-return valve and anti-lift lid. Pipes are fitted with non-return valves to avoid back-flow of sewage as well. A Mechanical Ventilation Heat Recovery (MVHR) system is installed in addition to natural ventilation which will aid drying out after a flood.

2.10 Other Structural Flood Prevention and Mitigation Techniques

- Do relevant checking and monitoring checks of the building structures in specific predetermined periodic intervals (maybe annually), depending on the location of the building, under the monitoring and targeting the resilience of the buildings to withstand against the natural hazards.
- A backup fire safety communication system should be installed in commercial buildings and residential housing apartment complexes. All such high populated and high rise buildings in flood zones should consider having a backup wireless fire communication system, and new large critical buildings must have backup phone and data connections. Mandate the use of storage batteries with a life of at least eight hours to serve buildings' fire and life safety communication systems. Also as another option, can use cogeneration and solar power

during blackouts due to natural hazard as a reliable backup power source. Remove barriers which restrict gaining solar energy and increase the allowable roof space for solar panels. Also residential stairwells, hallways and emergency exit ways should be kept lit during blackouts using the generated solar energy.

- In flood prone areas, storm water collection systems which can be integrated to rain water harvesting tanks or storages should be designed and installed to handle greater quantity of rain water. These storm water collection tanks can be installed either on roof tops or as underground mini reservoirs depending on the rainfall data of the site. Also this system can be developed in most of the buildings in urban areas and can integrate each underground mini reservoirs of the buildings and construct an underground water transmission tunnel which can reduce greater amount of flood hazards in urban areas. This concept has been applied by many developed countries like Japan to prevent flood hazards in their major cities.
- The reliance on public water systems should be reduced in case of emergency situations. Installation of redundant emergency networks of water supply and wastewater treatment by creating secondary facilities, redundant transmission-distribution pipelines or multiple water storage facilities. When it comes to solid waste management systems maintained inside the buildings, special care and safeguard should be given to the toxic materials storage units in flood zones. Toxic waste collection bins or stores in flood zones should be stored in a flood proof area which water can not be reached.

3. Non-Structural (Soft) DRR Mechanisms for Flood Preparation and Mitigation

There is no flood protection measure guaranteeing complete safety. In many vulnerable areas, sufficient flood protection cannot be reached with the help of structural means only. Hence, further flood risk reduction via non-structural measures is often indispensable. An optimal, site-specific mix of structural and non-structural measures is being sought. Non-structural flood protection measures include source control, zoning, insurance, flood forecast-warning system, awareness raising and improving information, etc. Few non-structural flood protection measures which can be incorporated in to the GREENSL® Rating System for Built Environment are discussed below.

- Assess site condition before design to evaluate sustainable options by completing and documenting site assessment on following;
  - ✓ Topography- Contour mapping, unique topographic features, slope stability risk.
  - ✓ Hydrology- Flood hazard areas, delineated wetlands, lakes, streams, shorelines, rainwater collection and reuse opportunities and initial water storage capacity of the site, etc.
- Watershed management (source control) modifies formation of floodwater. This concept includes land use and soil conservation to minimize surface runoff, erosion and sediment

transport, e. g. by terracing and contour ploughing, vegetation cover management and afforestation. The idea of "catching water where it falls" can be implemented by such measures as enhancing storage of water on the land surface, or underground, e.g. by infiltration (cf. Kundzewicz & Takeuchi, 1999). Enhancing retention counteracts such adverse effects of urbanisation as decrease of water storage potential, growth of impermeable area and flood peak, reduction of time-to-peak of a hydrograph. The notion of watershed management is central to the concept of natural flood reduction strategies.

- Check the resilience of the brownfield land for potential hazards before the redevelopment / Increase the resilience of the brownfield land in the brownfield redevelopment stage.
- Incorporation of an emergency handling section to the building user guide which covers the emergency response in potential hazards (Other hazards except fire). Also an emergency preparedness information and instructions manual to be developed for apartment residents and homeowners, including model emergency operating procedures and a building contact directory.
- Ensuring the community connectivity and transportation needs during emergency situations through creating alternative connectivity by creating connections with adjourning urban areas.
- Design public open spaces in low disaster risk areas, may be higher elevations to reduce flood risk for disaster resilience which public can gather during a hazard or an emergency situation.
- Introduce flood warning systems and sensors to detect floods and disseminate early warning alerts. For this, a series of water sensors are located outside the property and on entry points, linked to an internal remote alarm. Emergency rescue locations are designated at ground and first floor levels. Automation is essential to allow the various technologies to work in synergy and provide early warning, emergency contact and automatic safety measures. External door sensors and internal ground level sensor advises off the presence of water. All sensors are connected to a main sounder to give acoustic and visual warning. Potential to connect the main sounder to an automated call system / emergency authorities. Flood Emergency Kit to be stored on first floor.
- Awareness raising among general public about natural hazards, prevention and mitigations measures and preparedness mechanisms is a very important aspect. Improving information about floods is badly needed for awareness raising and enhancing the consultative process, which leads to a broadly acceptable flood protection strategy. Only informed stakeholders can make rational decisions about choice of strategies of flood protection, in cost-benefit framework; with the account of sustainability issues. Awareness raising should be an inherent part of a flood preparedness system.

- Input a section or module to the curriculum which is given to qualify as a green building accredited professional as well as as a compulsory module for university students in all higher education institutes in Sri Lanka.

4. Conclusions

The most common natural hazards in Sri Lanka include localized and seasonal floods and associated landslides while less frequent but more severe hazards include cyclones, droughts, and tsunamis. Out of those, floods are considered to be the most frequent, highest number of disasters reported and as well as which destroyed and damaged the highest number of buildings during recent past. Therefore it becomes a vital requirement to take necessary steps and DRR mechanisms for flood preparation and mitigation. This paper explains about globally used structural (hard) and non-structural (soft) techniques and mechanisms which can be applied for flood resistant buildings in Sri Lanka. The next step of this research study will be the incorporation of these identified flood mitigation and preparation measures and mechanisms into the GREENSL® Rating System for Built Environment through refinements to the sub-categories under main 8 categories rather than coming up with a new category or a separate code for DRR mechanisms. Also this research will be further extended to the other natural hazards such as landslides, strong winds and storms, etc. that Sri Lanka is more vulnerable into and they will also be incorporated to the rating tool.

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Annex 5: Conference Publication, International Symposium of Multi Hazard Early Warning Systems, Colombo Sri Lanka, March 2020 (Postponed)

A REVIEW ON INCORPORATING DISASTER RISK REDUCTION MECHANISMS FOR LANDSLIDE HAZARDS INTO THE GREENSL® RATING SYSTEM FOR BUILT ENVIRONMENT IN SRI LANKA

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Abstract: Landslides are one of the major disasters that occur throughout the world, causing great destructions to both human wellbeing and economic assets. Although many developed countries show a great progress in reducing loss of life, and in managing their economic and social adverse impacts from landslides, less developed mountainous countries, especially in Asia and Central America, still need more focus. Sri Lanka is a South Asian developing country, highly vulnerable to landslides, specially the island's central part due to its mountainous condition resulting about 1,077 deaths, 14,926 building disruptions and 291,964 human displacements during 1965 to 2019. Therefore, it becomes a vital necessity to design and construct sustainable disaster resilient buildings to withstand natural hazards. Although Sri Lankan Green Building Council has promoted sustainability and resilience, specifically through reducing resource usage and energy consumption, it has not properly incorporated Disaster Risk Reduction mechanisms into their green rating tool. Therefore, this paper is focused on identification of structural and non-structural DRR mechanisms for landslides which are to be incorporated into the GREENSL® Rating System for Built Environment through a comprehensive literature review. Site selection with proper slope stabilization, suitable building orientation and shape, constructing suitable earth retaining & slope stabilization structures such as embedded walls, anchoring and soil nailing etc., surface & sub-surface drainage networks, foundations to suit the slope and terraced buildings are few of the DRR mechanisms identified for landslides.

Keywords: Disaster Risk Reduction, Landslides, Disaster Resilient Buildings, Sustainable Buildings

Annex 6: Conference Publication, 11th International Conference of Sustainable Built Environment, Kandy, Sri Lanka, December 2020

A REVIEW ON DEVELOPMENT OF DISASTER RISK REDUCTION AND DISASATER RESILIENT GUIDELINES FOR HEAVY WIND HAZARDS IN SRI LANKA

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Abstract: Sri Lanka, being a tropical island situated near the equator between latitudes 5°and 10°N, and longitudes 79° and 82°E in the Indian Ocean experiences high temperatures and frequent rainfalls with winds almost throughout the year while the climate is dominated by the Southwest (May - September) and Northeast (December – February) monsoons. It also experiences first inter (March – April) and second inter (October – November) monsoon seasons while changes in the overall wind patterns of the monsoon seasons with different timeframes are possible and highly dependent on the behavior patterns of the Bay of Bengal. The most common natural hazards in Sri Lanka include floods and associated landslides while less frequent but more severe hazards include cyclones, heavy winds, droughts, and tsunamis. Out of which, eastern coastal belt stating from Mulathew area to Batticaloa area of Sri Lanka is highly vulnerable to heavy winds and cyclones. During 1965 to 2019, due to the heavy winds and cyclones around 292,563 buildings have been damaged and destroyed, about 2,425,704 people being affected and displaced and around $1,077,900 worth of economic losses have been caused only due to strong winds in Sri Lanka. Thus, constructing buildings and taking necessary Disaster Risk Reduction (DRR) and disaster resilient measures that can withstand against the natural hazards such as heavy winds and cyclones as well as for future climatic changes become a vital necessity to strive for a sustainable built environment. This research paper is a review which is focused on developing a set of guidelines using the structural and non-structural DRR and disaster resilient measures to withstand against the heavy winds and cyclones which can be incorporated into the GREENSL® Rating System for Built Environment in Sri Lanka. Site selection based on wind zonation maps, suitable building orientation and shape, tree plantation and installation of barriers to reduce the wind pressure, foundation design to withstand the pressure caused from wind forces and designing cross walls, openings such as doors and windows and most importantly roof design are few of the DRR mechanisms identified to withstand against heavy winds and cyclones.

Key Words: Heavy Winds and Cyclones, Disaster Resilient Guidelines, Sustainable Buildings

Annex 7: Conference Publication, 9th International Conference of Building Resilience, Bali, Indonesia, January 2020

Comparing the Enablers, the Barriers and the Gaps of the Coastal Hazard Resilience in Sri Lanka, Myanmar and Maldives

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ABSTRACT

Sri Lanka, Myanmar and Maldives are few Asian countries, vulnerable to many natural hazards such as Tsunami, earthquakes, landslides, floods, cyclones, storm surges and droughts. Sea level rise and coastal erosion are another two major coastal hazards, identified as slow processes which can cause severe vulnerability among coastal communities in long term. The objective of this research exertion is to come up with a comprehensive comparison of the coastal evacuation, coastal disaster resilience and disaster management frameworks by identifying the enablers, barriers and gaps in administrative policies and frameworks, use of technology in Disaster Risk Reduction (DRR) including the use of Multi-hazard Early Warning (MHEW) systems, implementation of policy related effective mechanism in evacuation planning, capacity building of the community, and the role of higher education in disaster management in each of the aforementioned countries. This paper is written based on a comprehensive literature survey, online questionnaire surveys and in-depth interviews and questionnaire surveys which were conducted among general public, vulnerable communities and government officials targeting the eventual outcome as to ascertain gaps and formerly to compare the disaster management frameworks of each country to identify the improvements and provoke suggestions and recommendations. As this paper comprehensively compare the enablers, barriers and the gaps in aforementioned segments of coastal disaster resilience in each country, the outcomes of this paper will be beneficial in coming up with better coastal disaster management frameworks and practices for each country as well as for the Asian region with a better understanding about positive and negative impacts of different approaches, practices and frameworks with a better preparedness for natural coastal hazards.

Key Words: Coastal Hazard Resilience, MHEW Systems, Enablers and Barriers, Disaster Management

1. INTRODUCTION

Sri Lanka is an island with central highlands and 103 river basins, vulnerable to many natural hydro-metrological hazards. Floods are recorded as the most frequent and highly vulnerable hazard by the island whereas the 2004 Indian Ocean Tsunami (IOT) was one of the deadliest coastal disasters in recent history, resulting over 230,000 deaths across more than 15 countries ranging across Asia to Africa (Suppasri et al., 2015). Sri Lanka was among the countries that were majorly affected as the tsunami hit at least 80% of the country's coastal belt. It caused 29,729 human deaths, displaced 889,175 number of people and over 79,100 houses were destructed while making it a major turning point in Sri Lankan Disaster Management Sector (Department of Census and Statistics, 2017; Disaster Management Center, 2018).

Myanmar is a country which regularly experiences cyclones, storm surges, floods, landslides, earthquakes, droughts and forest fires. Over the last 10 years, Myanmar has been exposed to 2 major earthquakes, 3 severe cyclones, floods and many other small scale hazards (Myanmar Information Management Unit, 2019). Same like Sri Lanka, Cyclone Nargis (2008) is considered to be the turning point for major developments and improves in Myanmar's MHEW systems and disasters preparedness which enclosed many acts, laws and regulations such as NDM Law (2013); MAPDRR (2012); Standing Orders on NDM (2009-2011) and MNFCDR while establishing many institutions as well. Myanmar was also affected by the 2004 IOT resulting 250 human deaths, 700 people were displaced and 300 houses were destroyed (T. T. Aung et al. and Kenji Satake et al.).

Consisting of 1,192 coral islands grouped in a double chain of 26 atolls, along the north- south direction, spread over roughly 90,000 square kilometers, makes Maldives the world's most dispersed countries while exposing it to many coastal hazards. Maldives is considered to be the country with the lowest elevation in the world, with maximum and average natural ground levels of only 2.4 meters and 1.5 meters above the mean sea level, respectively. More than 80% of the country's land is considered to be coral islands, rise less than 1 meter above the sea level makes Maldives highly vulnerable to the phenomena of sea level rise (Ministry of Tourism, 2015). Further the geographical location of Maldives which is near the Indian Ocean Ring where 2 main subduction zones, the plate boundaries near Sumathra in Indonesia and the Makran coast, generates large magnitude earth quakes which have a high risk of being exposed to Tsunamis as well. Apart from above hazards, Maldives is also affected by monsoonal floods, coastal erosion, salt water intrusion, strong winds and storms, etc (United Nation Development Programme, 2008).

Therefore, Sri Lanka, Myanmar and Maldives can be considered as few Asian countries vulnerable to many natural coastal and other hazards such as tsunami, earthquakes, landslides, floods, cyclones, winds, storm surges, droughts, sea level rise and coastal erosion. Also these 3 countries were affected from the 2004 IOT. This paper comprehensively describes about the enablers, barriers and gaps in administrative policies and frameworks, use of technology in Disaster Risk Reduction (DRR) including use of Multi-hazard Early Warning (MHEW) systems, implementation of policy related effective mechanism in evacuation planning, capacity building of the community and the role of higher education in disaster management in each of the aforementioned countries.

2. METHODOLOGY

Initially, a literature review was carried out to identify the status of the each of the countries, Sri Lanka, Myanmar and Maldives in segments of administrative frameworks and processes, use of technologies in MHEW systems and DRR aspects, evacuation planning, capacity building of the community and the role of higher education in disaster management by browsing the Websites of relevant authorities and referring to the research papers. Then during the visits in each of the countries, in-depth interviews and questionnaire surveys were carried out among general public, vulnerable communities and government officials of selected areas in each country to identify the improvements and provoke suggestions and recommendations about above mentioned segments.

In Sri Lanka, an initial data collection was conducted by interviewing key professionals who are actively involved in Disaster Management (DM) activities and academic staff of Higher Education Institutes (HEI) among eight participants, where each of them were presented with a questionnaire followed by a discussion. Key points were noted down through those interviews and discussions. Then a field observation was carried out in Dikwella Divisional Secretariat (DS) Division of Matara District, situated in the tip of the southern part of Sri Lanka which was heavily damaged by the 2004 IOT. During this visit, residents and administrative officials in two Grama Niladari (GN) (GN, is the smallest governing level in Sri Lankan state governance) divisions which are namely, Dodampahala East and Wattegama South, were interviewed using a structured questionnaire. The structured questionnaire was prepared focusing the 4 aspects; administrative policies and frameworks, use of technology in DRR, implementation of effective mechanisms in evacuation planning and capacity building of the community which were developed to cover and identify the most relevant gaps in the disaster management process. 39 interviews were carried out among self-employed personnel (including housewives), government employees, professionals (Doctors, Teachers), farmers, and fishermen which attempted to cover all community levels of general public and vulnerable communities.

Department of Meteorology and Hydrology (DMH), Department of Disaster Management and two villages namely Bu Gwe Gyi Village and Thazin Village (near Ngwe Saung) which were also affected from the 2004 IOT, were visited during the visit to Myanmar for data collection on the same 4 aspects of; administrative policies and frameworks, use of technology in DRR, implementation of effective mechanism in evacuation planning and capacity building of the community. During the visits to the above mentioned 2 villages, a discussion followed by an in-depth interviews and questionnaire surveys were carried out among the community heads and general public. The governance, organizational structure and the village level disaster management policies were determined during the open discussions and the interviews carried out. The same structured questionnaire, used in Sri Lankan questioner surveys was used for the interviews carried out in Myanmar as well for a better data analysis and comparisons.

During the scientific mission carried out in Maldives, Meteorological department, National Disaster Management Authority of Maldives and Maamigili village which is a relocation after 2004 IOT, was visited for data collection on the same 4 aspects of; administrative policies and frameworks, use of technology in DRR, implementation of effective mechanism in evacuation planning and capacity building of the community. During the visit to the Maamigili village, a meeting and a discussion were conducted with the village council followed by an in-depth interviews and questionnaire surveys among the community heads and general public. The governance, organizational structure and the village level disaster management policies were determined during the meeting, discussion and the interviews carried out. The same structured questionnaire, used in the questioner surveys carried out in Sri Lanka and Myanmar were used for the interviews carried out in Maldives as well for a better data analysis and comparisons.

3. ADMINISTRATIVE POLICIES AND FRAMEWORKS FOR DISASTER MANAGEMENT

Prior to the 2004 IOT, there were not much acts or policies related to disaster management or DRR in Sri Lanka. But Reconstruction and Rehabilitation Act No 48 of 1993 existed to provide relief to affected community, reconstruct property and rehabilitation of victims after a disaster. After the 2004 IOT, numerous legal frameworks have been developed to facilitate DRR and disaster management in Sri Lanka. Existing policies and acts with their objectives or purposes are tabulated in Table 01 below. In 2005, formation of the Disaster Management Act No 13 was the turning point of disaster management sector in Sri Lanka. It initiated the establishment of the National Council for Disaster Management (NCDM) and the Disaster Management Centre (DMC) in Sri Lanka (Jayasiri et al., 2018). It is also considered as the governing body of the disaster management structure in the country while establishing the NCDM as the supreme body in disaster management in Sri Lanka (Siriwardana et al., 2018). Figure 01 illustrates the structure of the NCDM (MDM,2005). When it comes to disaster management, Ministry of Disaster Management (MDM) of Sri Lanka works with numerous inline ministries and organizations under it while coordinating with the NCDM as well. Figure 02 shows the structure of the various departments under the MDM (MDM, 2019). With these overall upstream organizational structure, the Disaster Management Centre (DMC) acts as the focal point in coordinating lower level agencies as illustrated in Figure 03 (Hettiarachchi, 2008).

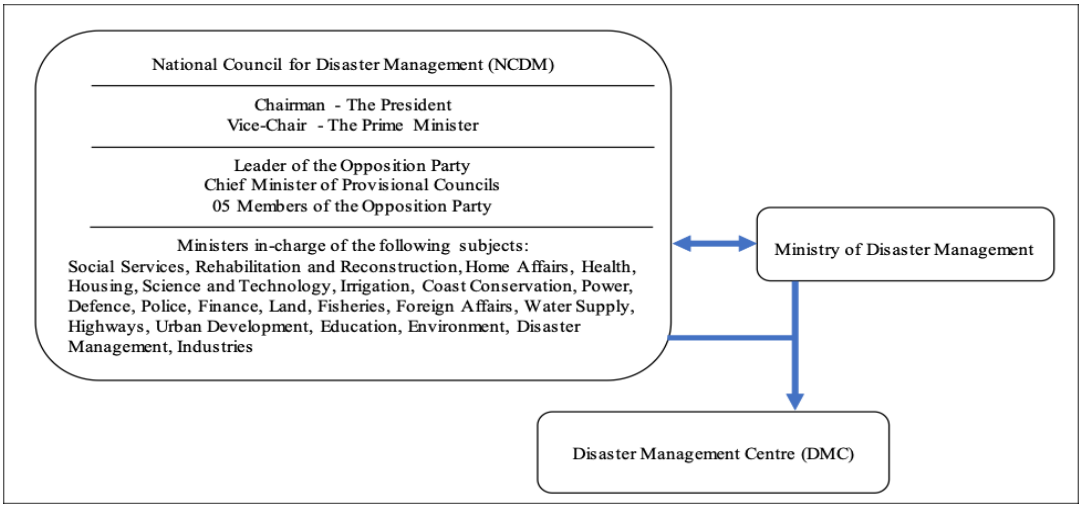

Figure 1: Structure of the NCDM (MDM

Table 1: Existing policies and acts related to Disaster Management in Sri Lanka with their objectives or purposes

Name of the Act	Purpose/ Objective
Disaster Management Act, No. 13 of 2005	Provides the institutional structure and governs the disaster management structure. And also defines the National Council for Disaster Management (NCDM) and DMC.
Reconstruction and Rehabilitation Fund Act, No. 48 of 1993	Use to provide relief to persons affected, reconstruct property and for rehabilitation.
National Policy on Disaster Management (NPDM)	Prepared according to the Hyogo framework for action in 2010. Make Sri Lanka to be as resilient and safe as possible from disaster risks
Sri Lanka Comprehensive Disaster Management Programme (CDMP)	This is the action plan for 2014-2018. Ensure the safety of Sri Lanka by reducing the direct and associated potential risk of the country and minimising impacts on people, properties and the economy
National Disaster Management Plan (prepared for 2013-2015)	Provides guidance to the formulation of the disaster management plans in all levels of administration. Reduce disaster impact on communities, infrastructure, lifeline facilities, shelter, agricultural property, economic and development activities in Sri Lanka
Climate resilient action plans for Coastal urban areas in Sri Lanka	Provide recommendations to the Sri Lankan cities to develop action plans to build disaster resilient cities based on the lessons learnt in the implementation of different project activities
Hazard Resilient Housing Construction Manual	Promote the use of hazard resilient engineering design and construction practices
National Adaptation Plan for Climate Change Impacts of Sri Lanka	Produce a comprehensive National Climate Change Adaptation Strategy (NCCAS) which lays out a prioritized framework for action and investment for 2018-2025 in line with United Nations Framework on Climate Change, aiming at systematically moving Sri Lanka and its people towards a climate change resilient future.
Coast Conservation Act, No. 57 of 1981	Provide for the formulation and execution of schemes of work for coast conservation within the coastal zone Make consequential amendments to certain written laws
Coastal Zone Management Plan (2004)	Capacity building for management, Controlling coastal erosion, Facilitating integrated management of coastal resources, Operating permit system and setback standards, Monitoring coastal water quality
Ministry of Finance and Planning	Budget Circulars No. 152 (I) (II) and (III): Issued in 2013 and 2014: to mitigate the duplication of funding.
National Emergency Operations Plan	Provides guidelines for emergency preparedness (2015)
Sri Lanka Disaster Management Plan	Prepared in accordance with Sendai Framework for the years 2018-2030.

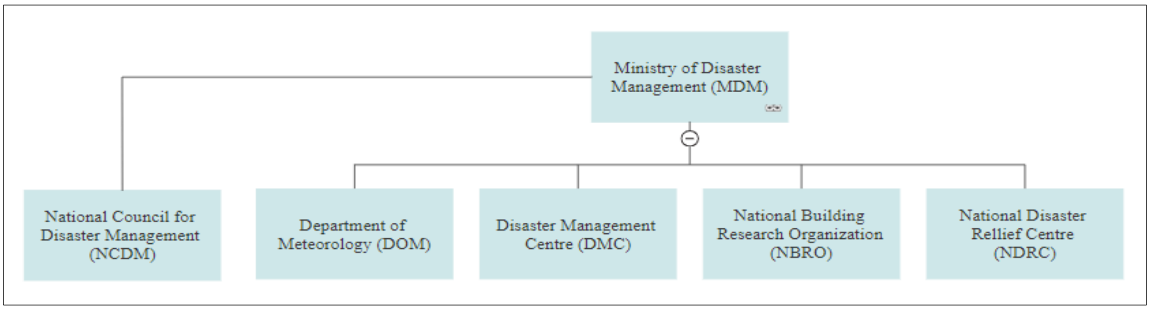

Figure 2: Structure of Various Departments under the MDM (MDM, 2019)

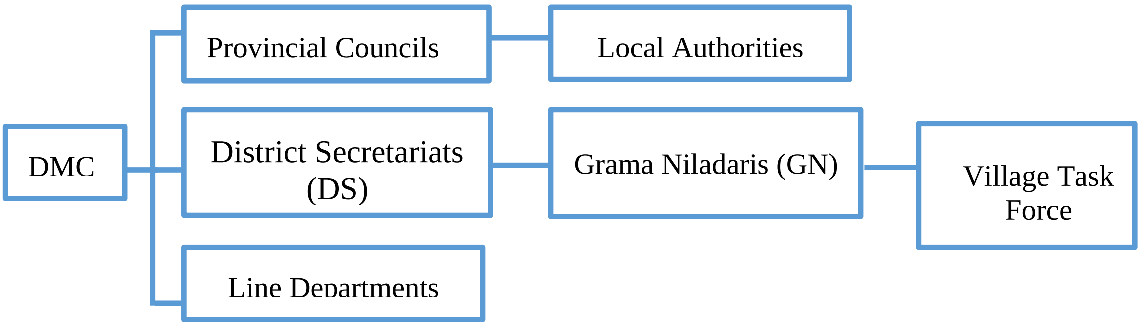

Figure 03: Coordination between DMC and lower level agencies (Hettiarachchi, 2008)

From the survey, it was identified that the involvement of external bodies such as the Armed and Police forces had played a vital role during and after the disasters; mainly in 2004 IOT. Therefore such external bodies can be identified as major stakeholders in the DRR process. But currently, there is a gap in linking those external stakeholders into to the DRR process and their impact on the process. During interviews with the administrative officials from the two GN divisions of Dodampahala East and Wattegama South, the officials expressed about the way that their role in disaster management becomes ineffective due to the ungoverned involvement of external bodies such as the Armed forces and political influences. Also a clear disorganization could be observed in distribution of funds and relief goods due to the lack of inclusion of such funding and relief agencies in the defined DRR process. Resettlement and relocation policies are not properly mentioned in the administrative process (Dissanayake et al., 2018). Many NGOs which participated in building permanent resettlement or restoration of damaged residences for victims displayed a lack of knowledge regarding property rights in the country, resulting in situations such as change of property ownership between spouses (Ruwanpura, 2009). Although most of the NGOs had put a time frame of two years for resettlement activities, in some parts of the country, victims of the 2004 IOT were residing in temporary shelters for about four years (Mulligan and Nadarajah,2012). Overall when considering the behavioral aspect of the disaster management policies and frameworks of Sri Lanka, they are administrative oriented rather than being community oriented.

National Disaster Management Centre (NDMC) acts as the focal point in coordinating lower level agencies in Myanmar. Myanmar Disaster Management Mechanism (Herein after DMM) complied from; Disaster Management Law, 2013

(The pyidaun gsu Hluttaw Law No. 21,1013) and Disaster Management Rules, 2015 (Notification no. 22/ 2015 from the Ministry of Welfare, Relief and Resettlement). Apart from these two, there is a set of policies to improve MHEW mechanisms in coastal resilience as well such as, Standing Order on Natural Disaster Management (finalized in January 2009 and updated in 2011) (ADPC, 2009), Myanmar Action plan on Disaster Risk Reduction (established in August 2009 and updated in 2012) (RRD, 2012), Natural Disaster Management (DM) Law (ratified on July 2013) and Myanmar National Framework for Community Disaster Resilience (2016). Also Myanmar has taken many global and regional policy initiates apart from national policies to improve MHEW systems. Table 02 below illustrate the implementation of global and regional policy initiatives in Myanmar. The coordination in disaster management in Myanmar is done under 5 administrative levels of the General Administration Department (GAD) namely, Village level, Township level, District level, Regional level and National level. In each level there are 12 working committees namely, Disaster management work committee, International relations work committee, Financing and financial management work committee, Search and rescue work committee, News and information work committee, Rehabilitation and reconstruction work committee, Health care work committee, Initial need assessment/ damage and lost verification and need identification work committee, Livelihood restoration work committee, Environmental conservation work committee, Security work committee and Logistics work committee. If a particular disaster strikes indicating a higher severity, then the response level will be advanced to the suitable upper level and they will be taken care of the situation. Not only the GAD, they coordinate with Department of Meteorology and Hydrology (DMH), Myanmar Red Cross Society (MRCS), Public Health, all TV channels, International NGOs and local NGOs and other responsible government ministries. The organizational structure of the disaster management bodies of Myanmar is shown in Figure 05. The Department of Disaster Management (DDM) was established in 2005 after the 2004 IOT. They work under the national disaster management committee which performs the duties in disaster management working committee. And they also have established the coordination between these 12 work committees. Overall when considering the behavioral aspect of the disaster management policies and frameworks of Myanmar, they are community oriented rather than being administrative oriented.

Table 02: The Implementation of Global Regional and National Level policy initiatives in Myanmar (Adopted from DRR (2016))

Global and Regional Initiatives	Policy Framework	National Legislation	National Development Strategy
Sustainable Development Goals 2015-30	Rural Development Strategy Framework (2014)	National Disaster Management Law (2013)	Election Manifesto, National League for Democracy (2015)
Sendai Framework for Disaster Risk Reduction 2015-30	National Social Protection Strategic Plan (2014)	Ward and Village Tract Administration Law (2012)	Framework for Economic and Social Reform (2013)
Paris Agreement on Climate Change	Myanmar Financial Inclusion Road Map (2015)	Environmental Conservation Law (2012)	
ASEAN Agreement of Disaster Management and Emergency Response	National Strategic Plan for the Advancement of Women (2013-2022)	National Framework for Community Disaster Resilience (2017)	
	Myanmar Action Plan on Disaster Risk Reduction (2009-2015)		

Figure 04: The organizational structure of the disaster management bodies of Myanmar

In Maldives, initial situational studies about disaster management and about related policies and frameworks were started around 1980s. After the Tidal Wave Incident, Suggestions from the workforce to the government of the Maldives were recommended to implement or set up specific institution for Disaster Management. After that, in the president's office a body within them have come up with a set of frameworks and guidelines with an institution to work on as Disaster Management Center. Before 2004, Maldives was a very peaceful country as they haven't faced many natural hazards. Therefore, the government of Maldives was not much bothered about the disasters until the 2004 IOT, which Maldives were considerably affected.

Maldives currently have the Disaster Management Act of Maldives since 2015 which have set the entire direction for the government towards disaster management which specify the responsibilities of the government or state and the citizens of Maldives. The purposes of the act are as follows; To protect the people from natural hazards and man-made disasters, To incorporate guidelines on disaster risk mitigation and preparedness, To reduce disaster risk and to adapt a preparatory national strategy, to identify responsible parties to manage disaster risk and to identify their responsibilities, To provide assistance at emergency situations and to provide assistance on the relief efforts while incorporating such guidelines to coordinate such assistance, To state the roles and responsibilities of the City Councils, Atoll Councils, and Island Councils in reducing disaster risk and mitigation in emergency situations, To create awareness among the people in reducing disaster risk and mitigation in emergency situations and to incorporate guidelines to protect the people from such dangers and enhance coping capacity, To incorporate disaster risk reduction guidelines and policies within the sustainable National development projects and To make the people responsible and accountable towards disaster risk reduction and mitigation. The existing governance framework is led by the National Disaster Management Authority (NDMA) and the president of Maldives along with the National steering committee which is a technical agency. For many reasons the establishment of NDMA was hold by the presidents of Maldives until 2018 December. But with the change of the government and the severe flooding occurred in Male, the current president of Maldives has taken steps to establish the NDMA by transforming the Disaster Management Centre(DMC) into the NDMA. There are lot of stakeholders involved with NDMA and some of them are, National Emergency Responses Forces (NERF), Maldives National Defense Force (MNDF), police, public health organizations, Maldivian recurrent. Early Warning mechanism is also guided by the Disaster Management Act of Maldives and it says that NDMA should have a national emergency operation plan in place which also needs to be revised every 5 years' time or periodically basis on disaster conditions that the country is facing. In early 2018, with the support of the World Bank and a Sri Lankan consultant team, the National Emergency Response Plan (NERP) of Maldives was completed and currently NDMA is working with other ministries to identify the major changes that should happen in the system and incorporate them into the NERP. NERP document has 2 volumes. Volume 1 is about Legislative Arrangements and institutional arrangements for emergency response in the country and coordination within the country. Volume 2 is about the analysis of functions before, during and after a hazard. Other than to the act there are three guidelines in place to drive the disaster management mechanism of Maldives. The three guidelines are;

1. Community Based Disaster Management (CBDRM) Framework
2. National Internally Displaced People (IDP) Framework
3. Mainstreaming Disaster Risk Reduction into local development (Country report and action plan)

Figure 05 below illustrates the existing upstream organizational structure of Maldives. Overall when considering the behavioral aspect of the disaster management policies and frameworks of Maldives, it is difficult to group them as administrative oriented or community oriented as still they are developing their national policies and frameworks.

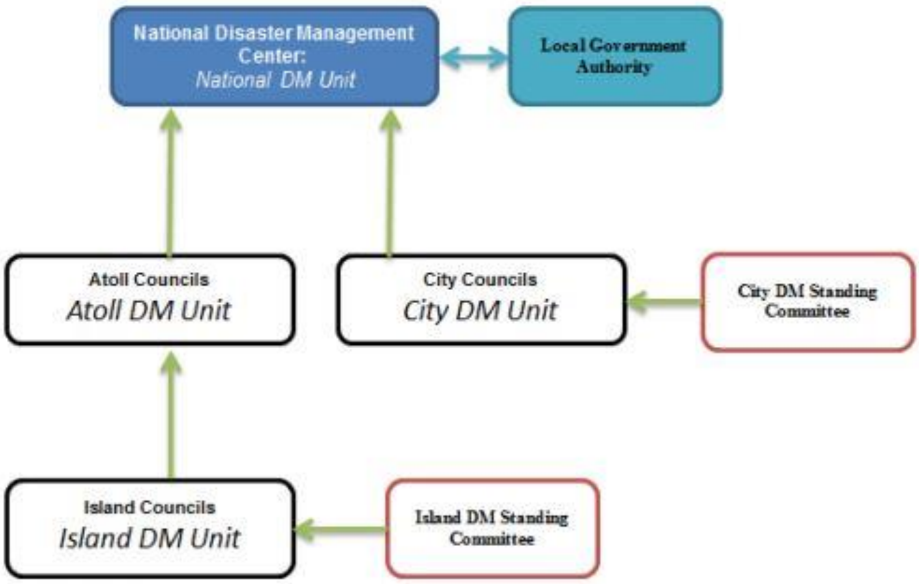

Figure 05: Existing Upstream Organizational Structure of Maldives

4. USE OF TECHNOLOGIES IN DRR

Currently numerous technological equipment and applications are used in DRR and disaster management considering each phase of the disaster life cycle. All most all the 3 countries considered, use or working on implementing Geographical Information Systems (GIS) to generate hazard maps and risk maps during the pre-disaster stage for an effective identification and illustration of vulnerable areas during disasters. This is already operated in Sri Lanka under the DMC and multiple line organizations and in Myanmar under the Department of Meteorology and Hydrology where as in Maldives still they are implementing GIS into their systems by the National Disaster Management Authority (NDMA) of Maldives. Global survey technologies available are used in analyzing and predicting possible disasters and then communicating to the government and citizens through Multi-Hazard Early Warning (MHEW) mechanisms. During the disaster and post-disaster phases, technologies such as drones are being used by many countries in identifying and rescuing victims. When it comes to Sri Lankan context DMC is the main body responsible for disseminating early warnings. Figure 06 below shows the existing MHEW dissemination system operated in Sri Lanka.

After the surveys conducted in Dodampahala East and Wattegama South GN divisions in Sri Lanka, the use of technology in receiving Early Warning (EW) messages was analyzed. The interviews with the GN officials and citizens revealed that the majority of the community still rely on more traditional methods of EW alerts compared to newer technologies. Their trust of the EW alerts are still mainly bound to mechanisms such as loudspeaker notification, bells and sirens, Early Warning towers and Short Message Service (SMS). According to analyzed data, EW towers and the loudspeakers are the most accessible mediums of MHEW systems to the general public whereas around 38% of the interviewees prefer loudspeaker, 31% prefer EW towers and 11% prefer SMS alerts which proves the above mention statement. From the same survey it revealed that, when it comes to Tsunamis, the highest preference regarding EW alerts is for EW towers. The DMC has established EW towers in each town at a prominent place in the area where the survey was conducted.

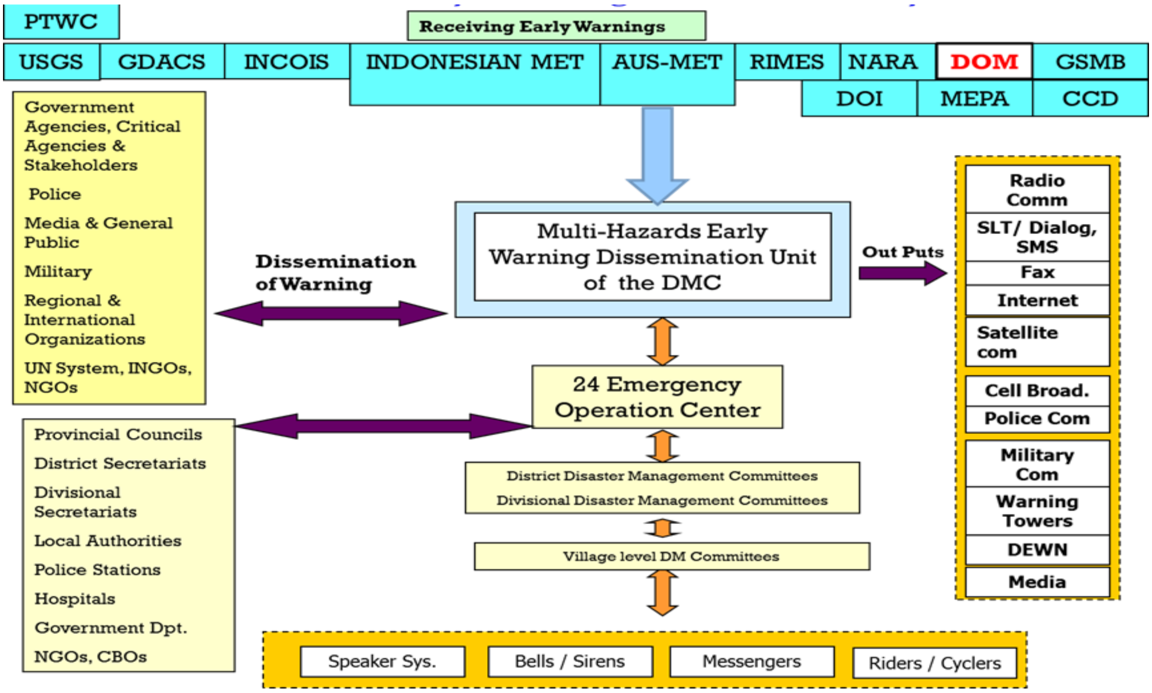

Figure 06: Existing MHEW Dissemination System Operated in Sri Lanka

SMS alerts are considered as a very frequent, convenient and a trustworthy mode of EW communication in many countries which have been highly affected by natural hazards. In Sri Lanka SMS alerts are also moderately preferred in the surveyed area. Another method which is in use is Social Media apps which enables the communication with larger number of people especially, during and after a disaster. Presently, mobile applications are being developed and used for the sole purpose of EW communication and other knowledge dissemination during a disaster. In Sri Lanka, such a mobile application exists, named the Disaster and Emergency Warning Network (DEWN) which was developed by a leading telecommunication company in Sri Lanka and operated by the DMC (Jayasiri et al., 2018). But only very few people have access to it compared with the Sri Lankan population due to lack of knowledge, awareness regarding the services and devices to access. The use of technology in ground level is low and specially a significant difference was observed in age groups. Younger generation is used to the technology and elderly crowd is not. These are major drawbacks in implementing such new technologies. Another important research finding of this survey is that, 60% of the survey respondents are reluctant to respond to EW messages due to various reasons such as reluctant to leave property, no faith on MHEW, no facilities in safe places and no protection motivation, etc. and 75% of them have no faith in EW.

When it comes to the Myanmar context, Department of Meteorology and Hydrology (DMH) is the main body responsible for measuring, analysing and disseminating MHEWs. They have established 3 weather radar stations in Yangon, Mandalay, and Kyaukpyu as well as 30 automatic weather observation stations all over the country by 2017 with the help of a Japanese donation. Also DMH maintains 27 Hydrological Stations and 44 Hydro-meteorological stations and issues flood forecasts for 30 stations in Myanmar. Currently, Relief and Resettlement Department (RRD) is working on a project which is implementing an end-to-end early warning system in collaboration with DMH. Phone, fax, Viber, SMS, television, radio, Single Side Band of (SSB), and loud speaker are their devices used in MHEW system in Myanmar.

In the seismology division of DMH, 23 staff members are working on monitoring the seismic activities and issuing the early warnings. The organization serves since 2004 and they have been successfully engaged in the recent hazards, specially for the earthquakes, occurred in 2011, 2012, 2016 and 2018. Because of the less productivity and efficiency in conventional monitoring mechanisms of seismic activities, they have managed to advance the technology from analog stations to digital stations. After implementing four digital stations, the issues of taking a long process time and low accuracy in monitoring had been overcome. Seismology division is also working on improving the repairing process and time during the breakdown of seismic stations. Introducing of new software like Siescomp3 and Antelope (Antelope is an integrated collection of programs for data collection and seismic data analysis, and typically runs at the central processing site. It has been in development for over a decade and is deployed around the world) is another initiative that they have taken for the improvement in DRR. DMH plans to enhance their performance by installing sirens for Tsunami early warnings which are currently not installed in Myanmar. Furthermore, they are planning to work collaborative with China Geological Survey Bureau (CGSB) for further improvements. Since the research and development in DRR is not substantial, they plan to initiate more research with university students and government to invent and explore new technologies for a better DRR. Moreover, although there are 30 seismic stations installed, currently most of them are not functioning properly. Therefore they plan to repair them and install new seismic stations as well. In future, DDM plans to initiate Disaster Alert Notification (DAN) software; a mobile application that bridges the information gap on disaster risk communication in Myanmar. The new mobile application; DAN, provides warnings to communities in times of disaster as well as notifications, important news, Do's and Don'ts for prevalent hazards, and contact numbers that the general public can contact during emergencies. The application also provides a link to the website of the DMH which users can also refer to weather forecasts and early warning information. These initiatives will reinforce the disaster preparedness of the vulnerable communities in Myanmar.

During the surveys conducted in Bu Gwe Gyi Village and Thazin Village in Myanmar, it was generally identified that the preferred systems for early warning by the community are Radio and TV whereas Door to Door and Loud speakers being the traditionally used systems. But results from the survey showed that, 26% prefer loud speaker, 24% prefer TV and radio and 17% for SMS alerts as the source of early warning dissemination method. Therefore, loud speakers can be identified as the warning method that communities are most likely to respond. All most all the interviewees had their trust and faith on existing early warning dissemination methods and early warning messages and alerts which are issued and they are willing to leave their properties and belongings behind and evaluate for safe shelters. Through couple of interviews it was identified that, reluctance to leave property and agricultural lands as the most likely reason for families to stay in the households even after receiving the warning. The lead time between the disaster and the point of early warning stayed 2-3 hours for Tsunami and for coastal hazards of storms it was two days at most.

In Maldives, the Meteorological Department of Maldives is the main governing body for monitoring and issuing early warnings for the whole country. According to Meteorological Department of Maldives, the most efficient communication modes in Maldives are social media, mobile app and SMS alerts as more than 90% of the citizens use smart phones. They also use a radar system for monitoring purposes and planning to integrate all the monitoring systems to one main system for an efficient service. They also have a separate land phone communication system which is to be used during an emergency, each land phone dedicated to each organization in emergency response such as, Air Port, Emergency Operations Centre (EOC), National Disaster Management Centre (NDMC), Television Maldives (TVM), Radio (VOM), Pacific Tsunami Warning Centre (PTWC), Maldives National Defense Force (MNDF) and Police. They maintain an automated alarm system to be operated when the Richter magnitude of an earthquake is greater than 5, followed by a Standard Operating Procedure (SOP) when the Richter magnitude of an earthquake is greater than 7. They don’t have sirens Tsunami warning towers in the islands to issue early warnings. When it comes to the mobile application they are using, they use real time data updates and release notifications to the users in two languages which are Dhivehi and English. Also recently Meteorological Department has created a community Viber group to deliver early warning messages and within 7 months they have reached 14826 participants in it, which clearly emphasis that people are more into smart phone technologies rather than conventional modes of communication. They maintain a backup power system for emergencies using generators.

During the council meeting and the survey conducted in Maamigili island in Maldives, it was revealed that the Madifushi island community had been relocated to Maamigili island after the 2004 IOT, by that time, they had no early warning system dedicated to Madifushi island with respect to Tsunami. TV or Radio was the only method available at that time and people had no idea about natural hazards like Tsunami or early warnings. Now the council and the community of Maamigili Island get information and have direct access to data and updates about early warning alerts regarding natural hazards through TV, radio, SMS, mobile application and Viber group available. Also through the interviews conducted it revealed that they don't have sirens or Tsunami early warning towers in Maamigili island.

5. EFFECTIVE MECHANISMS IN EVACUATION PLANNING

Implementation of effective mechanisms in evacuation planning is a key segment in DRR and disaster management as it could minimize the adverse effects through such disasters. In the presence of thorough evacuation planning and training mechanisms, there is a chance of preventing the damages and losses caused as a result of natural hazards; specially for human. Evacuation shelters also play a major role during a disaster by providing a safe refuge during the disaster and reducing the urgency in rehabilitation and reconstruction. If evacuation shelters are poorly and insufficiently planned, the lives of the affected people become difficult.

In Sri Lanka, after the 2004 IOT, several awareness seminars and training drills were conducted for the general public in each GN division by DMC with the government. The main aim of these drills is to make citizens aware of natural hazards; specially Tsunamis and practice them with skills required for safe evacuation. From the survey conducted in Dodampahala East and Wattegama South GN divisions, it was revealed that members of each GN division were divided into few groups during the initial training programs and each group was assigned with a specific role or a duty during a disaster such as door-to-door disaster warning and rescue of differently abled and elderly persons, etc. From the results of the survey, it was determined that there is a lack of participation of the general public for the EW drills and awareness camps. This means that current public knowledge about natural hazards and practices used for evacuation planning is very low. DMC has also instructed the citizens to maintain an evacuation goodie pack which includes their National Identity Card (NIC), valuable certificates and other small scale valuable belongings and place it in a prominent and an easily accessible place in their home as a part of the evacuation plan as in case of a disaster or an emergency, people can quickly evacuate with this goodie pack. However, in present context, only a very few practice this. The survey also revealed that 40% of the residents are reluctant to evacuate from their properties during a disaster. One reason for this is due to fear of thievery, due to robberies had been occurred during the 2004 IOT and during few drills that were conducted afterwards. Another reason is the lack of faith in EW systems. May be due to the fact that in the past few false alarms were given and some training drills had been conducted without informing the public, which public was given an idea that an actual disaster would occur. The third reason is the lack of necessary facilities and safety in evacuation shelters. In the survey area evacuation shelters are considered to be community building in high lands such as temples and schools. In Dodampahala East GN Division, the temple is denoted as the evacuation shelter of the division. When it comes to Wattegama South GN Division, the division has named a natural rock which is situated in a higher elevation from mean sea level as the evacuation point and the rock has been named as 'Tsunami rock'. One of the major gaps identified is that the strength and the structural stability of the evacuation shelters after occupied with the vulnerable community and the structures, found along the evacuation routes such as bridges. Another major gap identified is that, lack of sufficient capacity and basic needs like water and sanitary facilities to satisfy the whole vulnerable community stays in these evacuation shelters. Also, another gap identified was that the newly constructed schools and other public buildings such as hospitals and community halls are being constructed in lowlands, making them unsuitable to be used as evacuation shelters during coastal disasters.

As stated in previous sections, the Department of Disaster Management (DDM) is the main governing body for evacuation planning in Myanmar. According to DDM they have a separate training center for evacuation planning and they perform awareness sessions and drills for the vulnerable communities and general public to raise the knowledge and awareness about natural hazards and evacuation plans to be practiced during an emergency. During an emergency, the message to evacuate will be taken and released by the DDM along with the General Administration Departments (GAD). The reports from the DMH and other international organizations will be compared and warnings will be issued accordingly and occasionally. During the questioner survey and the discussion carried out in Bu Gwe Gyi Village and Thazin Village. It was reveled that, almost the entire community of villages were aware about the evacuation shelter as monastery in that village as it is the highest place that can be found in the village. The villagers also have identified the safest and quickest route to the evacuation shelter from the household. In 2011, one village had had a 3 day awareness camp and a training drill to aware and prepare the community for a safer Tsunami evacuation. Other than that no training drills or awareness programs were carried out. Also during the survey, it revealed that the community is willing to leave their properties and evaluate for evacuation shelters during an emergency or early warning alert. Also there were hardly any development activities been carried out in the coastal area to reduce coastal disaster risk. Yet recently electricity was introduced to Bu Gwe Gyi village and Thazin village is out of electricity yet. Same like Sri Lanka major gaps identified in the evacuation mechanisms and shelters are, structural stability of the evacuation shelters and the adequacy of structures along the evacuation routes to occupy the whole community in the village and lack of sufficient space, capacity and basic needs to satisfy the whole vulnerable community in the village during a disaster.

According to the National Disaster Management Authority (NDMA) of Maldives, until 2004 IOT hit, there is not any clue of implementing any evacuation mechanisms in the whole country. Further they stated that, Around 2007, Maldives had the first disaster risk profile done for 10 key islands with the support of United Nations Development Program (UNDP). Those risk assessments were used for planning and understanding of what sort of disasters that the Maldives will have a risk of going through. Disaster Management Center (DMC) or currently named as NDMA has started to work with organizations such as UNDP, Asian Disaster Preparedness Centre (ADPC) and Mercy International and have started a program called Community Based Disaster Risk Management (CBDRM) Program. Currently, in 52 islands, they have conducted the initial CBDRM activities. NDMA has reviewed their old process and have come up with the CBDRM version 2.0 with better performance. Now the CBDRM 2.0 has been integrated with the program of island disaster management plan as a tool. Also NDMA has established local disaster management committees and community emergency response teams and have looked into how early warning mechanisms and communication systems can be established and practiced in the islands while evacuation planning exercises are also performed in the islands. CBDRM

2.0 has been started to develop in 2017 and have worked in 4 islands using this newly developed tool during 2018 and 2019. But 50 other islands have been covered through the old version of CBDRM. Due to the rapid changes and developments happening in Maldives, especially in the islands, the CBDRM tool must be revised in a way suitable for the current context and the future trends in the country. NDMA is also responsible for moving people during an emergency. For 54 islands, which they have completed the disaster management plan, they have a database which mentions all the details about the resources available in each island such as number of trained people available with their details, available resources (such as water drainage pumps and firefighting equipment) and people whom to coordinate. For islands where the planning is not done yet, it is difficult to communicate and coordinate during a disaster. With the response and advises getting from NDMA, island councils can work on their own plans, but they have to inform and coordinate everything to the NDMA. Each council has their own SOP and mechanisms which have coordinated with NDMA. Currently, NDMA has taken many national and city level initiatives in DRR activities. One of them are, school programs based on Tsunami which provide the knowledge about natural hazards that the Maldives is more vulnerable into and the proper training drills are provided to school children. Community based programs can be identified as another initiative of NDMA which provides the awareness and trainings with a certificate for the delegation. With these initiatives the NDMA also faces many challenges as well. The trained people won't retain due to the knowledge and certification received, as they move to different islands and resources for jobs. Therefore maintaining the trained team is difficult during an emergency. Therefore, a new mechanism should be introduced and implemented to sustain the trained teams. Resources such as drainage pumps, firefighting equipment should be provided to Island council levels to work their own without waiting for forces. During the discussion and the survey conducted in the Maamigili island, it revealed that, a sea wall has been constructed to protect the island mainly as a result of the airport development. The island is safe from Tsunami as of today and acts prone to most coastal hazards. The community is much aware about the evacuation route for evacuation shelters which are considered to be mosques and schools. During the initial period after the 2004 IOT, couple of training drills and awareness sessions have been carried out and no drills have been conducted in recent past. Also the community has no specific plan to evacuate people with special needs such as disable and elderly people during an emergency. It was also identified that the same gaps exist in Maldivian evacuation mechanisms and shelters similar to Sri Lankan and Myanmar surveys which are, structural stability of the evacuation shelters and the structures along the evacuation routes to occupy the whole community in the village and lack of sufficient space, capacity and basic needs to satisfy the whole vulnerable community in the village during a disaster.

6. CAPACITY BUILDING OF THE COMMUNITY

Although floods are recorded as the most frequently affecting natural hazard type in Sri Lanka, 2004 IOT is considered to be one of the deadliest coastal disasters in recent history, resulting over 230,000 deaths across more than 15 countries ranging across Asia to Africa (Suppasri et al., 2015). The earthquake which generated the Tsunami had a magnitude of M_w 9.3, making it the first "extreme" earthquake since the 1964 earthquake (Stein and Okal, 2007, 2005). This catastrophic disaster caused many adverse effects to the vulnerable community such as, damage and loss of property, the inward flow of seawater into drinking water sources and agricultural lands and the destruction of carriers; especially for the community who were involved in trade, agriculture, and fishery industries. Restoration of businesses took 2 months, restoration of agriculture took 6 months and restoration of fisheries took even longer as even after one year, only 40% had been restored (Suppasri et al., 2015). Out of the interviewees from Dodampahala East and Wattegama South GN divisions, 31.5% said that that they did not return to the same career as they had to start their carriers in a different path of work afterwards. The people who started their carriers in the same path reported that they took time periods ranging from a few days to 5 or 6 years to return to work. However, 77% of those people returned to their work by three months. As immediate post-disaster management operations, many organizations such as police and tri forces, staff from local administrative divisions such as the GN divisions, media organizations, and NGOs such as the Red Cross and UNDP were involved in rescue operations to find those displaced during 2004 IOT. Out of the interviewees, 92% responded that provisions like dry rations, potable water, basic sanitary facilities and other supplies were supplied by NGO's immediately after the disaster. The government was also involved in providing supplies through the relevant administrative levels. 2004 IOT also caused many damages to the infrastructure systems in the area such as electricity lines were damaged, contamination of inland water sources with the inward flux of sea water, many buildings were destroyed including essentials like hospitals and the transportation systems were blocked. According to the survey results, the average time taken to restore electricity was ten and a half days, to have access to portable drinking water sources was nine days on average. By September of 2005, pipeline water provision was restored to all citizens who were served prior to 2004 IOT (Illangasekare et al., 2006). The time taken to restart using the transportation systems after the disaster had taken six days averagely. The complete replacement of damaged assets was estimated to cost nearly USD 2 billion (Jayasuriya et al., 2006). The government had assessed the losses and compensation were made to the vulnerable community in different ways such as monetary support as a compensation, a new house in the same location and a land with a house to resettle elsewhere. Out of the interviewees, 74% reported that at least some physical damage was repaired. A major observation from the survey in Dikwella was that according to the community, 65% of the interviewees believed that they stand at a lower level prior to the tsunami and they were not happy with state they are compared with the state they were before the disaster. This may be mainly due to the Sri Lankan community has evolved in a welfare-oriented culture, where the citizens mostly depend on external help to recover rather than building up by their own.

In Myanmar, DDM is the governing body for capacity building, rehabilitation and reconstruction. They have a separate disaster management training center in terms of capacity building. It is important to highlight about the built-up of the households in both villages; Bu Gwe Gyi Village and Thazin Village after the 2004 IOT. Most of the houses were built from wood about few feet above the ground level using supports. Number of positive aspects were identified about these structures, including better air circulation, better heat transferring, better placement against natural disasters like floods and safety from ground animals etc. Community had had an understanding about the adverse impact on their carriers, agricultural lands, properties and other income methods during a disaster. During the interviews, most of them reported that their carriers will be disturbed when a disaster strikes. For an example, in one village most of the people were engaged in coconut farming industry and during disasters the coconut trees used to fall and they loose their carriers. During a disaster, immediate actions were taken from villagers themselves and the village administration committee. Other than that GAD, Fire brigade and municipalities help during a disaster as humanitarian support. But it was clearly highlighted that villagers themselves take care of the community. Results of the survey revealed that most of the time, community failed to identify any involvement from local governance structure during a hazard, other than dissemination of early warnings and delivering of information regarding a hazard. Also the basic need acquiring was rated as the highest emergency need of the people. Community was not aware about a mechanism or a process to estimate damages after a coastal hazard. The general procedure was again that villagers help each other to build back from damages by themselves. But they also stated that there are few non-government organizations like youth associations who help the community during and post disaster period. According to interviewees of the villages, they had the access for drinking water just after a disaster. Although they say that they use well water as drinking water even after floods have been dried out, the quality of the drinking water is questionable. Also when it comes to electricity, in Bu Gwe Gi village, new hotels and resorts have been constructed and electricity have been given because of the tourism industry. Since, power lines were added very recently like 1 month back, people did not have a clear experience on how long it takes to restore the electricity and other infrastructure. For the Thazin village, they still do not have electricity and they totally depend on oil lamps. A major observation from the survey in these two villages was that according to the community, 53% or the majority of the interviewees believed that they stand at a higher level prior to the 2004 IOT and they were happy with state they are compared with the state they were before the disaster. This may be mainly due to the Myanmar community has evolved in an empowered community culture, where the citizens try to recover and build up by their own rather than seeking for external help or welfare.

During the discussion conducted with NDMA of Maldives, it was stated that, during the initial period of 2004 to 2008 after 2004 IOT, reconstruction and relief operations were carried out by DMC and other institutes related to disaster management which were established by the president of Maldives during the same period. These organizations were given the lead to manage the relief and recovery operations during a disaster which also includes integration between different organizations, reconstruction and rehabilitation. MNDF, UNDP, Red Cross and many NGOs from different countries were involved in rescue, relief and rehabilitation operations after 2004 IOT. As mentioned in previous sections, Mamigili island was used as a relocation place from Madifushi Island after the 2004 IOT. Madifushi island had had a high impact from the Tsunami and the island was abounded until recently a construction of resort was started. Most of the income methods of the community were destroyed, mainly due to Madifush was completely abounded. With the rehabilitation in Mamigili island, new income methods were created around the island. It can be considered as a transfer of work from Madifushi to Maamigili. Also community stated that the current level of work, working condition and income methods are better at

Maamigili, rather than the state they had in Madifushi back in 2004. Another point to be highlighted is that, the relocated community own the relocated lands for themselves. As mentioned during the council meeting of Mamigili, the land ownership is awarded after considering number of criteria and eligibility by the government of Maldives. Also government had contributed to construct the houses with the funds they received in the awarded lands of the community together with few volunteering business men who acted in a responsible manner after 2004 IOT disaster. During the reconstruction of houses and other public facilities, the community has actively involved in construction work. Also volunteers have provided the community with evacuation equipment such as boats, temporary shelters to stay during the reconstruction period and job opportunities for those who were in need. A major observation from the survey in Mamigili island was that according to the community, majority of the interviewees believed that they stand in a higher level or they have built back better prior to the 2004 IOT and they were happy with state they are compared with the state they were before the 2004 Tsunami disaster. This may be mainly due to the Maldivian community has evolved in an empowered community culture, where the citizens try to recover and build up by their own rather than seeking for external help or welfare which is mostly similar to Myanmar context.

7. ROLE OF HIGHER EDUCATION IN DISASTER MANAGEMENT

In Sri Lanka, during the interviews and discussions carried out with key professionals who are actively involved in Disaster Management (DM) activities and academic staff of Higher Education Institutes (HEI), it revealed that most of the initiatives towards the disaster management field have been taken only after the 2004 IOT. The knowledge and the awareness regarding natural hazards like Tsunamis, cyclones and earthquakes were very minimal among the public and as well as among the professionals and university students as well. According to the experts, education curriculums could integrate social learning processes that deals with coastal resilience to hazards and Integrate the topic to student projects in fields such as civil engineering, coastal and environmental engineering, sustainable development would enrich engineering education with other useful topics such as social designs, long-term perspective, resilience, vulnerability etc, which current Sri Lankan higher education is lacking. Most of the certificate programs available in Sri Lanka incur a high cost. Therefore, sponsorships and funds are required to enhance the participation. Private sector and NGOs participation is considerably high compared with the public sector. Few other suggestions which Sri Lankan HEIs are lacking, were raised up during the interviews such as, cross-disciplinary and transdisciplinary research on MHEWS should be encouraged, innovations must be low cost and community focused with the ease of implementation, sufficient funds should be allocated for this sector, research dissemination should be web based even though it is not the current trend in Sri Lanka and the collaboration between industries, HEIs and government should be strengthened to uplift the research, innovations and development in the disaster management field.

When it comes to Myanmar context, Universities in Myanmar play an important role for giving awareness to the public, nurturing scientist and conducting MHEW related research. Although it is clearly mentioned in the existing laws and regulations, implementation is still very weak at the university level. Lack of funding, poor inter-ministerial cooperation and lack of human resources are the main challenges that HEIs of Myanmar is facing today. Professional and higher education institutional experts believe that cooperation among related ministries and networking with more advanced universities for technology and funding are important and the possible ways to overcome such barriers.

The Maldives National University is the main university available in Maldives as a HEI. During the discussion that was conducted with Maldives National University academic staff and experts in Disaster Management field, it was revealed that, role of HEIs in disaster management is very minor. Further they said that, hardly any studies or researches have been conducted specific to the role of higher education in disaster management as well. Although globally HEIs play a major role in DRR and disaster management, In Maldives specific role for Higher education sector is not even been mentioned in DRR frameworks developed by National Disaster Management Centre and Environment Ministry. But specific and possible roles for primary and secondary educational institutes or schools are mentioned in those DRR frameworks. General public do not perceive disaster management as an important area to pursue a carrier. As a result, there is no demand for courses in this field in the Maldives. Low demand by the public for disaster management courses seems very risky for most Higher Education Institutes to offer courses in this field. Therefore, there is hesitation within the Higher Education Institutes to introduced courses related to the field of disaster management in the Maldives. Currently Maldivian NDMA is working on identification of required research areas to be developed and doing research on these areas such as flooding and its pattern, effects due to sea level rise and climate change, etc. NDMA also looks for long term sustainable partnerships with universities and academia as research partners and industry partners to mitigate the disasters and build up disaster resilient constructions in Maldives.

8. CONCLUSION

2004 IOT was the major turning point in Sri Lankan and Maldivian disaster management sectors where as it also made a huge impact in Myanmar disaster management sector as well. Formation of the Disaster Management Act No 13 and establishing DMC as the focal point in coordinating lower level agencies in disaster management were among the main improvements happened in Sri Lanka. NDMC in Myanmar and NDMA in Maldives act as the focal point in coordinating lower level agencies in their countries. The Disaster Management Act, 2015 of Maldives enabled many disaster management mechanisms in Maldives. Overall when considering the behavioral aspects of the disaster management policies and frameworks of each country,

- Sri Lanka: Administrative oriented
- Myanmar : Community oriented
- Maldives : Can not rate due to many major developments are still carrying out

Loud speakers are identified as a major impactful and effective early warning system in both Sri Lanka and Myanmar. But proper resource allocation and a standard operational procedure for the loud speaker method should be made available in each community level and also constant training, drills and practical usage should be tested frequently. When it comes to Tsunamis, the highest preference regarding EW alerts is for EW towers in Sri Lanka. Engineering solutions are required to improve the range of EW towers. A technological sharing of such systems within the region and outside the region will be helpful for both Sri Lanka and Myanmar in updating EW towers. TV and radio are popular in both Myanmar and Maldives although some communities do not have electricity in Myanmar. SMS, mobile application and Viber group are among the most preferred mediums of EW alerts in Maldives while they have no EW towers established yet. Necessary actions should be taken to build the faith on MHEW systems in Sri Lanka as 75% of them have no faith in EW alerts. Temples, schools and community centers are the main evacuation centers used by the Sri Lankan community where as monastery is used by Myanmar community and mosques and schools are used by Moldavians as their evacuation shelters. Strength and the structural stability of the evacuation shelters and the structures, along the evacuation routes such as bridges are questionable. Another major gaps identified in evacuation shelters of these 3 countries are that lack of sufficient capacity and basic needs like water and sanitary facilities to satisfy the whole vulnerable community while newly constructed schools and other public buildings such as hospitals and community halls in Sri Lanka are being constructed in lowlands, making them unsuitable to be used as evacuation shelters during coastal disasters. Unplanned resettlements were one of the major drawbacks observed in Sri Lanka as they were low budget housings with less quality, problems with livelihood restoration and construction time frame lagging. A major observation from the surveys conducted in 3 countries is that, majority of the Sri Lankan interviewees believed that they stand at a lower level than prior to the 2004 tsunami and they were not happy with their current state while the majority of the community in Myanmar and Maldives believed that they stand at a higher level prior to the 2004 IOT and they were happy with their current states compared with the state they were before the disaster. This may be mainly due to the Sri Lankan community has evolved in a welfare-oriented culture, where the citizens mostly depend on external help to recover rather than building up by their own whereas Myanmar and Maldivian communities have evolved in an empowered community culture, where the citizens try to recover and build up by their own rather than seeking for external help or welfare. It has been revealed from the professional experts in all 3 countries that the role of HEIs in disaster management sector is not in a satisfactory level in their countries and in Maldives, it is in a very minimal level compared with the other 2 countries due the low demand by the public for disaster management courses, making it very risky for HEIs to offer courses in this field. Professional and higher education institutional experts believe that cooperation between industries, HEIs and government should be strengthened while HEIs are networking with more advanced universities for technology and funding are important and possible ways to overcome such barriers to uplift the research, innovations and development in the disaster management field.

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10. DISCLAIMER

The European Commission support for the production of this publication does not constitute an endorsement of the contents, which reflects the views only of the authors, and the Commission cannot be held responsible for any use, which may be made of the information contained therein.

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Annex 8: Journal Publication, International Journal of Disaster Resilience in the Built Environment, January 2020

Barriers and Enablers of Coastal Disaster Resilience – Lessons Learned from Tsunami in Sri Lanka

Abstract:

Purpose - This research exertion evaluates the coastal disaster resilience and the Disaster Management Framework of Sri Lanka, by conducting a case study in a few coastal areas in the district of Matara which were majorly affected in 2004 by the Indian Ocean Tsunami. Although it has been 15 years since the disaster struck the country, Sri Lanka is still struggling in building back better. This reveals the need to strengthen the action plan towards coastal disaster management by identifying the barriers and challenges that still exist in policies and frameworks, the use of technology in evacuation planning, implementation of evacuation plans and capacity building of the community.

Approach/Methodology – The study was conducted through structured and in-depth interviews among the general public and government officials targeting the eventual outcome as to ascertain barriers incorporated with the disaster management framework and then possible improvements to the framework were identified and suggested.

Findings - The findings showed that the practice of an administrative-oriented disaster management framework was a key element in creating a welfare-oriented community that is still building back better in Matara, which was one of the worst affected cities in the country during the 2004 Tsunami.

Originality/Value - This paper facilitates resilience development by identifying the overall development of the system after 2004. The required modifications needed to strengthen the system have thereby been identified through the developed output which was produced by analyzing the barriers and challenges.

Key Words: Disaster Management Framework, Coastal Disaster Resilience, Barriers and Enablers

Paper Type: Case Study

Introduction

The 2004 Indian Ocean Tsunami (IOT) was one of the deadliest coastal disasters in recent history, resulting in over 230,000 deaths across more than 15 countries ranging across Asia to Africa [54]. The earthquake which generated the tsunami had a magnitude of M_w 9.3, making it the first “extreme” earthquake since the 1964 earthquake [55], [56]. Sri Lanka was among the countries that were majorly affected as the tsunami hit at least four-fifths of the country’s coastal belt. It caused 29,729 human deaths, displaced 889,175 number of people and over 79,100 houses were destructed [57], [58].

Prior to the 2004 IOT, the disasters induced by natural hazards which largely affected the country were floods and landslides, with floods being the major disaster affecting Sri Lankan citizens. Since Sri Lanka had not experienced tsunamis in the recent past prior to 2004, the country was woefully unprepared to face such a disaster [59]. This was one of the reasons for the high number of losses, as Sri Lanka did not possess any standard tsunami Early Warning mechanisms at the time [11].

The studies done by Burbidge et al. (2008), Latief et al. (2008) and Jankaew et al. (2008) have shown that the return period of a tsunami with a magnitude similar to that of the 2004 IOT will be between 520 years to 1000 years. Yet after the 2004 IOT, several other earthquake-generated tsunamis have occurred in the Indian Ocean, in the years of 2005, 2007, 2010 and 2012. Each of the earthquakes had magnitudes equal to or greater than M_w 8.0 [54]. Since 2004, Sri Lanka was not affected by these tsunamis, hence the preparation and risk reduction focus on Tsunami risk has decreased compared to the other countries in the region (Rathnayake et al., 2019). However, the knowledge and the awareness of the citizens regarding tsunamis and preparation to face them must be continuously maintained.

The main aim of this research study was to identify barriers and challenges in the disaster management mechanism and to evaluate the context of the affected communities at 15 years after the disaster. Another major focus was given to evaluate the capacity of the whole system to face another disaster of the same kind. The context of the study here is the coastal community that experienced the 2004 Tsunami in the Matara area, which is situated in the Southern province of Sri Lanka. The term system is used to include the multiple stakeholders in the community, which includes community residents, administrative officers, government processes, and non-governmental organizations. The affected community, volunteers, divisional secretariat office and other relevant governing organizations are some of the elements of the defined system. The organizations, communities, and individuals who do not function during the undisturbed state of the system were recognized as the external elements. Identifying the overall development of the system after 2004 and required modifications to produce an output that facilitates further resilience development in the country was the community contribution of this research study.

Methodology

This paper is part of a broader study in analyzing the Disaster Risk Reduction (DRR) process considering tsunamis. It discusses the field observations of the case studies carried out in the Dikwella District Secretariat (DS) Division, which is situated in the Matara District which was heavily damaged by the 2004 IOT. Residents and administrative officials in two Grama Niladari (GN) Divisions, Dodampaha East and Wattegama South, were interviewed. A GN Division is the smallest governing level in Sri Lankan state governance. The interviews were conducted using a structured questionnaire regarding the following four aspects which were developed to cover and identify the most relevant barriers in the disaster management mechanism; policies and frameworks in DRR, the use of technology in DRR, implementation of evacuation planning and capacity building of the community. The 39 interviewees consisted of self-employed personnel, professionals (such as doctors and teachers), farmers, and fishermen. Furthermore, administrative officers who have had experience in past disaster events were also interviewed.

Policies and Frameworks for Disaster Management in Sri Lanka

Prior to the 2004 IOT, the Reconstruction and Rehabilitation Act No 58 of 1993 existed to provide relief to affected persons, reconstruct property and rehabilitation of victims in the aftermath of a disaster. After the 2004 IOT, a number of legal frameworks were developed, in order to define and facilitate disaster management in Sri Lanka. In 2005, the Disaster Management Act No 13 was formed. It provided for the formation of the National Council for Disaster Management (NCDM) and the Disaster Management Centre (DMC) (Jayasiri et al., 2018). It is used to govern the disaster management structure in the country. The NCDM was established as the supreme body in disaster management in Sri Lanka [65]. Figure 1 illustrates the structure of the NCDM [66].

Sri Lanka has also defined other policies and guidelines for disaster management such as the National Policy on Disaster Management (NPDM), which looks at increasing the country’s resilience against disaster risks, the Comprehensive Disaster Management Programme (CDMP), which provides a comprehensive investment plan in order to minimize the impact on the citizens’ livelihood and the country’s economy in the face of a disaster, the National Disaster Management Plan (NDMP), which looks into reducing the impact of a disaster on various aspects of the country such as communities, infrastructure, economy and development activities and the National Emergency Operation Plan (NEOP), which provides the Standard Operating Procedures (SOPs) to be used by all associated agencies in time of a disaster (Jayasiri et al., 2018).

In the context of disaster management, the Ministry of Disaster Management (MDM) of Sri Lanka works with a number of inline ministries and organizations in activities of DRR and it also coordinates with the NCDM. Figure 2 shows the structure of the various departments under the MDM [67]. With these overall upstream organizational structures, the Disaster Management Centre (DMC) acts as the focal point in coordinating lower-level agencies as illustrated in Figure 3 [68]. The line departments mentioned here are the Ministry of Health, Department of Irrigation, Forestry Department, Ministry of Defence, Coast Conservation and Coastal Resources Management Department, Ministry of Industries, etc.

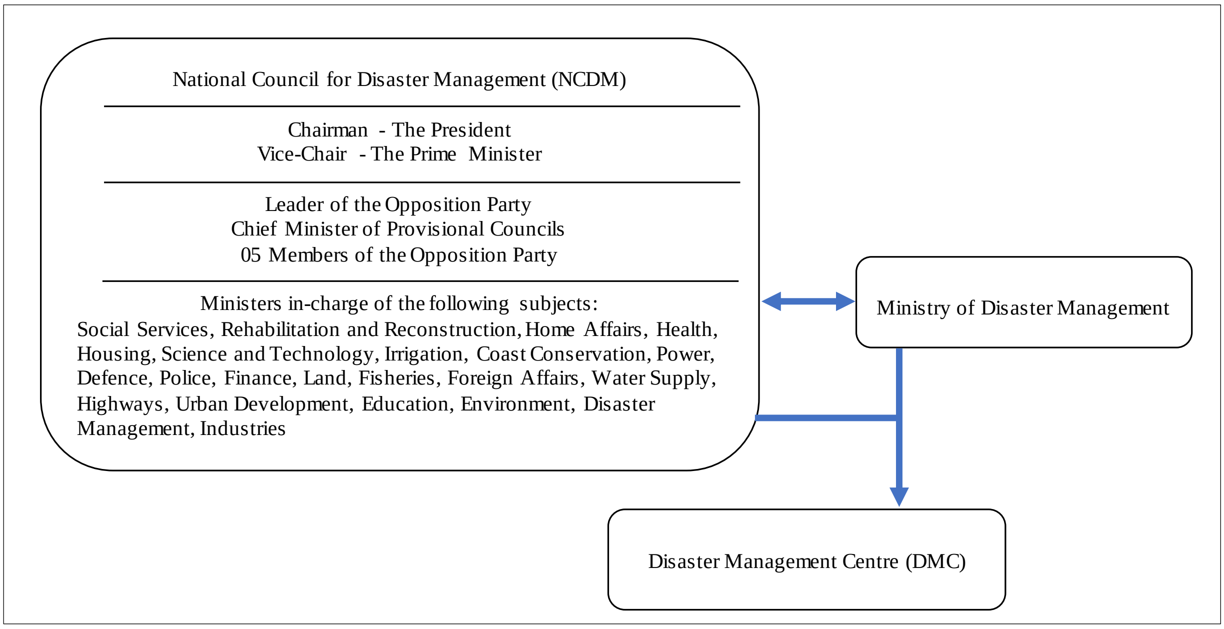

Figure 1: Structure of the NCDM [66]

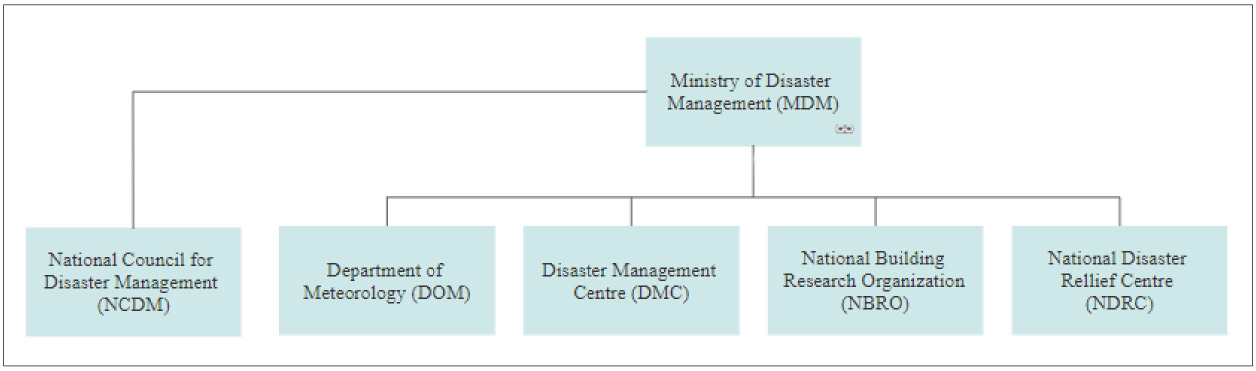

Figure 2: Organizational Structure of the MDM [69]

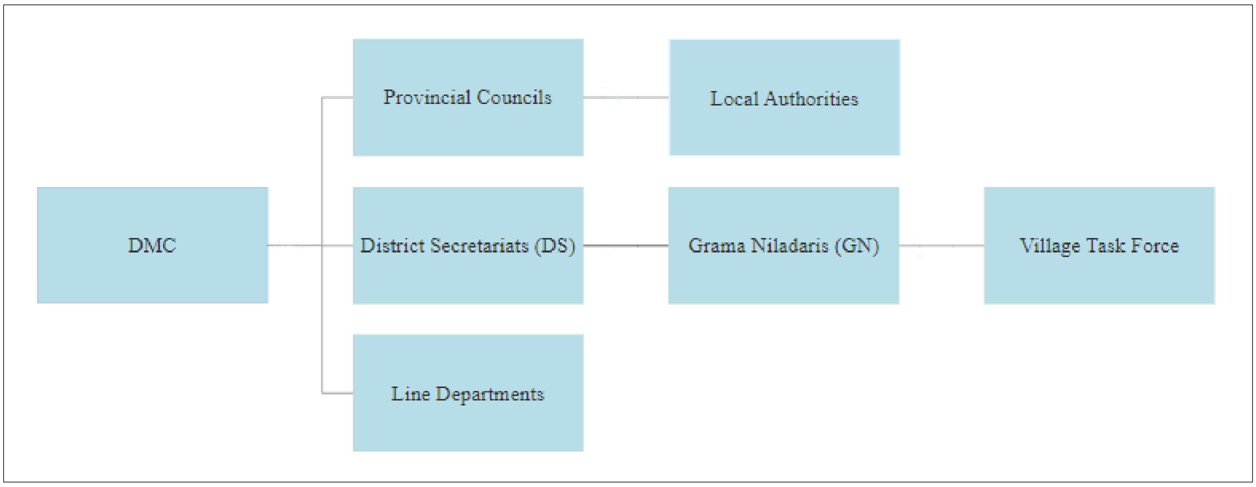

Figure 3: Coordination between DMC and lower-level agencies [68]

When observing the defined administrative processes in Sri Lanka, it is evident that the involvement of external bodies, such as non-governmental and voluntary communities were excluded from the Disaster Management frameworks. However, their influence and intervention are crucial in Disaster Management. One such focus area is humanitarian assistance [70] as was seen during the aftermath of the 2004 IOT, where over 500 international aid organizations were involved in recovery and rehabilitation work [71]. In the course of the study, it was identified that the participation of external bodies such as the armed and police forces had played a vital role during the post-disaster period. Therefore, such external bodies can be identified as major stakeholders in the DRR process. As such, there is currently a discernible gap in linking them to and governing their impact on the DRR process.

During interviews with the administrative officials from the two GN divisions, the officials expressed their discontent at the way their role in disaster management becomes ineffective due to the involvement of external bodies such as the armed forces and political influences. This directly showcases the negative impacts due to the gap in the inclusion of helpful external bodies.

Another point of interest is the support gained from private organizations in evacuation planning in terms of technology and monetary aspects. There has been clear disorganization in the distribution of funds and relief items, possibly due to the lack of inclusion of such funding and relief agencies in the defined DRR process. The administrative process can be strengthened by facilitating increased coordination between such private organizations and the relevant governmental agencies.

Land use planning and resettlement and relocation policies in the administrative process are also major problematics areas [72]. Many NGOs that participated in building permanent resettlement or restoration of damaged residences for victims displayed a lack of knowledge regarding property rights in the country, resulting in situations such as change of property ownership between spouses [73]. Also, most of these NGOs had put a timeframe of two years for resettlement activities. However, in some parts of the country, victims of the 2004 IOT were residing in temporary shelters for up to four years [74].

Effective Use of Technology in Disaster Risk Reduction

The technological advancement over the world has resulted in the development of existing mechanisms to deliver EW alerts towards the vulnerable community level. Different web-based and mobile-based applications have evolved in order to make the existing platforms more efficient and convenient for usage by the layperson. These advancements can be incorporated in each stage of the DRR cycle to perform efficient functioning.

During the pre-disaster stage, Geographical Information Systems (GIS) can be used to generate hazard maps and risk maps in order to effectively identify and illustrate vulnerable areas during disasters. With these technological advancements around the world, the need of updating the Multi-Hazard maps in Sri Lanka was identified as a key parameter to enhance the resilience level of the country (Jayasiri et al., 2018). But, the accuracy of the development of Multi-Hazard maps varies with the return period of each hazard category which is to be integrated with reference to the existing base maps. This can be identified as another research area that can be explored and undertaken under the concept of Multi-Hazard Early Warning (MHEW).

Numerical simulation studies were carried out by researchers to identify the tsunami mitigation measures with respect to structures [76]. This is already in operation in Sri Lanka under the DMC and multiple line agencies. Global survey technologies combined with computer-aided simulations, big data analysis and database analysis of past disaster incidents can be used to analyze and predict possible disasters and communicate to the government and citizens through MHEW mechanisms. During the disaster and post-disaster phases, technology such as automated drones can be of use in identifying and rescuing trapped disaster victims with minimal danger to rescuers.

Under this research study, a major focus was directed towards the identification of community exposure towards different modes of receiving Tsunami Early Warnings (EWs) and the awareness of modern approaches. The structured interviews with the GN officials and the community revealed that the majority of the community still relies

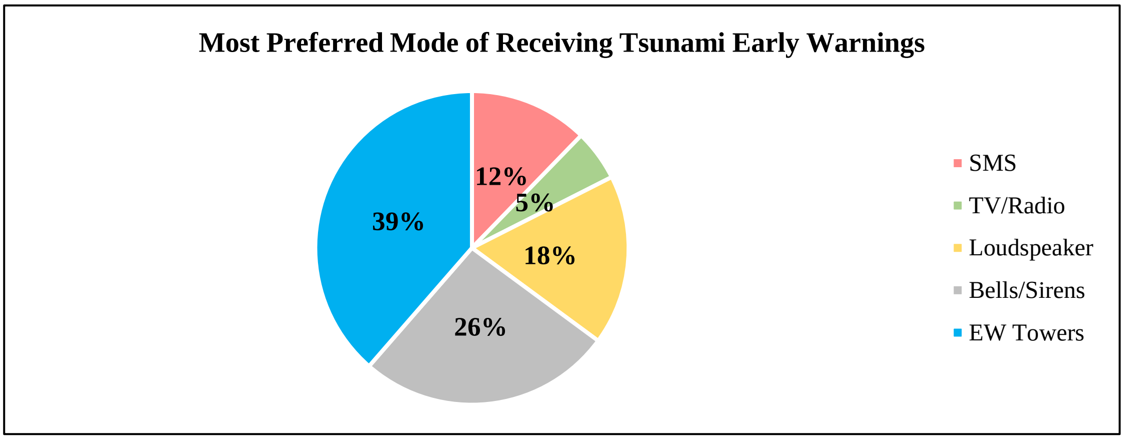

Figure 4: Community response on the most preferred mode of receiving Tsunami Early Warnings

on more traditional modes of receiving EW alerts compared to novel digitally enhanced applications. This can be interpreted more in Figure 4.

From the analyzed interview responses, the most preferred mode of receiving Tsunami EWs can be extracted as the notification disseminated through the EW towers. This was preferred as the best option by 39% of the responses received.

The DMC has established EW towers in each major town in the coastal zone at prominent places. The EW tower in the Dikwella DS Division has been established in the Dikwella Police Station, as denoted by (1) in Figure 5. during the interviews, the administrative officials revealed that the siren had been audible up to a maximum distance of 1000m during the drills that had been conducted. The audible area is marked from the black circle in Figure 5. The EW tower is 2.83 km away from Dodampahala East GN Division (3) and 432 m away from the Wattegama South GN Division (2). Mobile EW alarm systems (vehicles with sirens attached) are available for other areas.

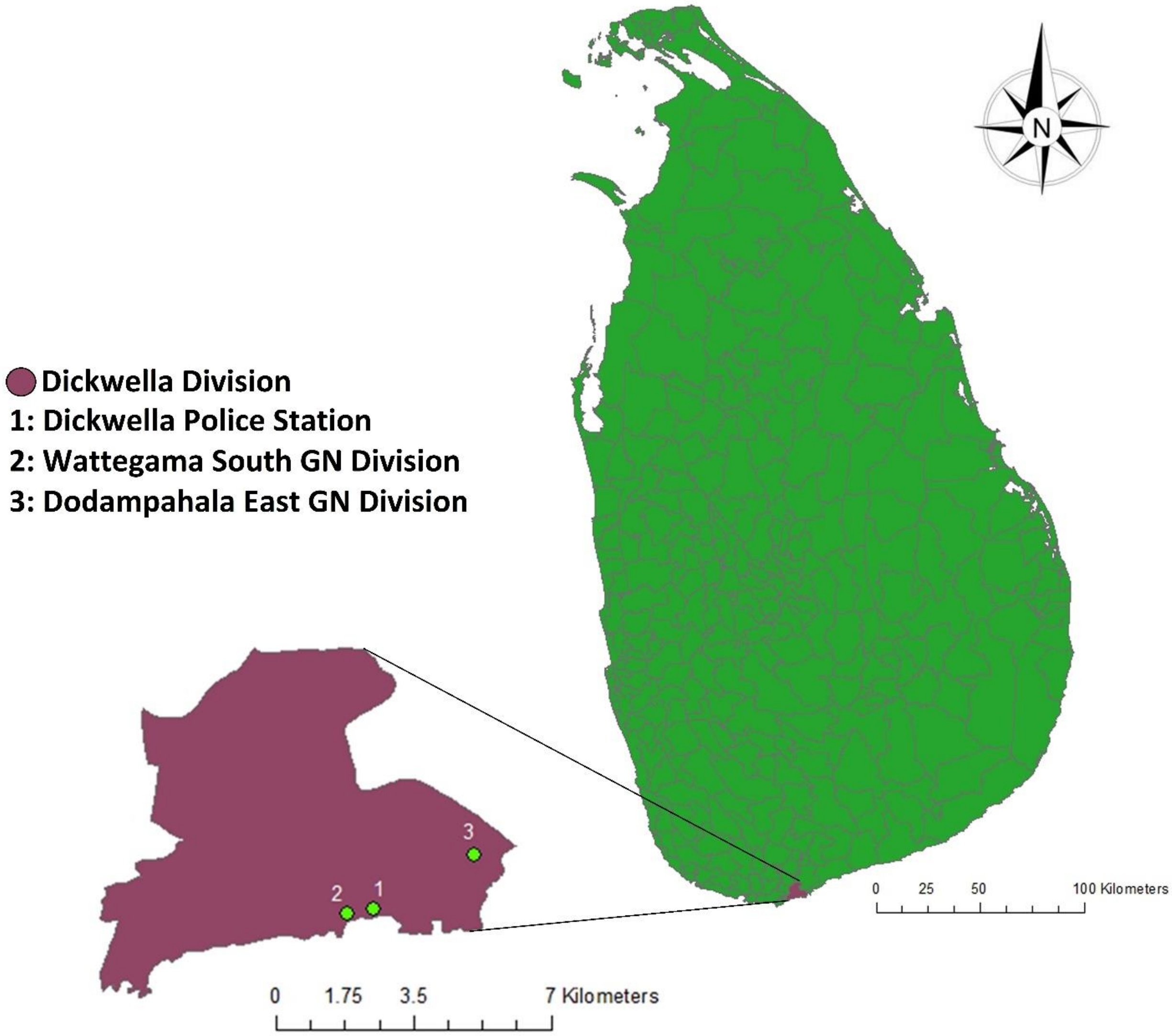

Figure 5: EW tower location and GN Locations in Matara Dickwella

Next to the warnings given by the EW towers, the majority of the community has shown a preference for the traditional modes of EW. Amongst them, Bells or Sirens, Loudspeakers and TV/Radio ranked the highest preferred, exceeding the preference for the modern digital platforms. The low mobile phone and smartphone usage in the community, lack of awareness regarding modern digital platforms and credibility issues of the information received from the other modes can be considered as main reasons behind the interview responses.

Social media platforms like Facebook, Twitter have ranked as the most efficient modes of delivering EWs in other countries over the world [77]. However, when comparing this fact with the obtained data set, the preference for social media when receiving the tsunami EW was almost null. This has revealed that the exposure and the willingness of the community to adapt to new changes are considerably at a lower level. The lack of knowledge and the awareness of modern digital communication platforms associated with Tsunami EWs can be considered as probable reasons for these community responses.

Short Messages Service (SMS) is used frequently and has become a trustworthy mode of EW communication in many countries which are highly affected by coastal hazards. Considering the community response of the study location, the receival of tsunami EWs through SMS has been listed as the most preferred method by 12% of the responders.

Another identified platform, which is highly used among the community in other countries is Social Media apps which enable communication with a larger number of people, especially during and after a disaster. Presently, there are also mobile applications that are being developed for the sole purpose of EW communication and other knowledge dissemination during a disaster. In Sri Lanka, such a mobile application exists, named the Disaster and Emergency Warning Network (DEWN) which was developed by a leading telecommunication company in Sri Lanka and operated by the DMC (Jayasiri et al., 2018). For such services to be fully utilized, the providers need to fully incorporate and integrate the available facilities and technology.

During the study, it was observed that there is a lag in the usage of digitally enhanced communication platforms in the community area of the study. this highlights a lack of exposure and awareness regarding services such as DRR relevant mobile applications. The use of technology at the grass-root level is low and a significant difference was observed in the technology usage between the younger and older age groups. The elderly population in the community do not show a significant usage of common technology available, whereas millennials do. This tends to be a major drawback in implementing such technologies. One of the initial research findings indicated that 60% of the interview respondents were reluctant to respond to EW messages and 75% of them have no faith in the EWs received.

Implementation of Evacuation Plans

Disaster Evacuation

Implementation of evacuation planning is a key segment that is considered under Coastal Disaster Resilience and Management in order to minimize the effects of such disasters. In the absence of thorough planning and training, there is the chance of damage and loss occurring that could have otherwise been prevented. For example, during the 2005 Nias Earthquake and Tsunami, about 10 people died due to panic when the evacuation was being conducted from the Sri Lankan coast [54]. Another point to be remembered in DRR planning is that the majority of the victims during disasters such as the 2004 IOT were women and children [59]. Therefore, the safety of women and children during evacuation planning should be a priority.

After the 2004 IOT, several training drills had been organized for the general public in each GN division by the government. The DMC frequently organizes EW drills in order to educate people who live in high hazard-potential areas. The main aim of these drills is to make citizens aware of tsunamis and for them to practice skills needed for safe evacuation during a coastal hazard such as a tsunami. From the study, it was gathered that during initial training programs, members of each GN division were divided into groups, with each group being assigned a specific duty during a disaster. These duties included door-to-door disaster warning and rescue of differently-abled and elderly persons. From the results of the interviews, a lack of participation of the general public in EW drills and awareness camps was detected. This means that current public knowledge about coastal disasters and practices used for evacuation planning has slowly reduced.

As part of evacuation planning, the DMC has instructed citizens to prepare and maintain an evacuation pack, which should include their National Identity Cards, valuable governmental certificates, and other valuables and store it in a prominent place. This is so that in case of a disaster or emergency, people can quickly evacuate. However, the interview results indicate that only 18% of the interviewees currently follow this practice.

The study in the two GN divisions revealed that 40% of the residents are reluctant to evacuate from their property during a disaster. One reason for this is due to fear of thievery, as during the 2004 IOT many robberies occurred and the same was repeated during a few past drills. The second reason is the lack of faith in EW systems. This could be partly due to the fact that in the past, a few false alarms had been given. There had also been several instances where training drills had been conducted without informing the public, allowing them to think that an actual disaster would occur. The third reason is the lack of necessary facilities in safer locations.

Evacuation shelters

The presence of planned evacuation shelters, in addition to providing safe refuge during the disaster, reduces the urgency of rehabilitation and reconstruction, so that those activities can be done in a well-planned and durable manner. When such shelters are poorly planned and insufficient for the evacuated population, the lives of the shelters' residents become difficult, especially those of women's and children's lives. [74].

In the study area, evacuation shelters are based on a community building in high land. It was observed from the interviews that people tend to take shelters from the nearby temple in Dodampahala East GN Division. The temple has been denoted as the evacuation shelter of the division. There the facilities are the next important factor. Depending upon the time of stay the capacities are determined.

When the community is located more inland, residents deemed it safe to stay in their houses given the assumption that the houses are at a higher elevation. A major example is the Wattegama South GN Division, marked by (2) in Figure 5, which is situated about 500 m away from the coastal line and is at a relatively high altitude. The area does, however, have an evacuation point named by the GN division, which is near a natural rock and the rock has been called the Tsunami Rock.

A major gap identified is that the structural stability and the strength of the structures which are found in evacuation routes such as bridges as well as the buildings used as evacuation shelters for vulnerable communities. These evacuation shelters lack sufficient capacity and basic facilities like water and sanitary facilities to satisfy all the vulnerable members in the area. Also, another gap identified was that the new constructions of schools and other public buildings are being in lowland areas, making them unsuitable to be used as evacuation shelters during coastal disasters.

Capacity Building of the Community

The damage and loss of property, the inward flow of seawater into agricultural land and the destruction of marine life in the ocean made the return to career life after the tsunami extremely hard, especially for people involved in trade, agriculture, and the fishing industry. Restoration of businesses took 2 months, restoration of agriculture took 6 months and restoration of fisheries took even longer as even after one year, only 40% had been restored [54]. Out of the interviewees, 32% reported that during the time of the disaster, they had no idea how it would affect their methods of income. From the people who were involved in a career at the time of the Tsunami, 31.5% reported that that they did not return to the same career or started in a different path of work afterward. The people who did resume in the same path reported that they took time periods ranging from a few days to 5 or 6 years to return to work. However, 77% of those people returned to their work by three months after the tsunami.

In terms of immediate post-disaster management after the 2004 IOT, many organizations were involved in search and rescue operations to find those displaced during the disaster. These organizations include the army, navy, air forces and police, staff from local administrative divisions such as the GN and DS divisions, media organizations, and NGOs such as the Red Cross organization. The immediate aftermath of the disaster also required the provision of supplies like dry rations, potable water, and other supplies. Out of the interviewees, 92% responded that provisions were supplied by NGO’s. The government was also involved in providing supplies through the relevant administrative levels.

The IOT caused many damages in the infrastructure systems in the area. The electricity lines were damaged and cut off, the inward flux of seawater caused the water sources to be contaminated and unusable, the transportation systems were blocked off and the public transportation systems were put on hold. From the interview results, the median level of time taken to restore electricity lines was ten and a half days. The time taken to access drinking water without provisions had a median level of nine days. By September of 2005, pipeline water provision was restored to all citizens who were served prior to 2004 IOT [78]. The time taken to restart using the transportation systems after the disaster had a median level of six days for the people in the studied communities.

The damage and losses caused by the Tsunami were extensive and costly to the people. The complete replacement of damaged assets was estimated to cost nearly USD 2 billion [59]. The government became involved in various ways to help the affected citizens. The damages and losses were assessed, and compensation and reparations were made to the people in terms of monetary support and equipment supply. Figure 6 shows the satisfaction of the people regarding government involvement during the aftermath of the 2004 tsunami aftermath as a score out of ten.

The government mechanism for re-establishment and restoration of damages and losses for the tsunami-affected was as follows. First, the affected person had to file a police statement stating the list of damages and losses. Then the government assessed damages and reparations were given in terms of monetary support to build back the losses or a new house or land to resettle elsewhere. Out of the interviewees, 74% reported that at least some physical damage was repaired.

Administrative officers regretfully stated that most of the affected community in Matara, Sri Lanka has evolved into a welfare-oriented culture, where the citizens completely depend on external help to recover from the 2004 IOT disaster. A major observation from the study in Dikwella was that as a whole, the community currently stands at a lower level when compared to its status prior to the tsunami. The citizens have not reached a full recovery state, in terms of the yearly income and household states.

After the Tsunami, a 3 km long retaining wall has been constructed along the coastal line in the Dodampahala area. The coastal line in the study area has been marked as a protected area. However, there have been a series of constructions in that area, mostly hotels and restaurants. While many industries in the coastal zone experienced a downward growth rate following the Tsunami, the growth rate of the construction sector increased from 5.5% to 8-10% in the following 3 years after the 2004 IOT [79].

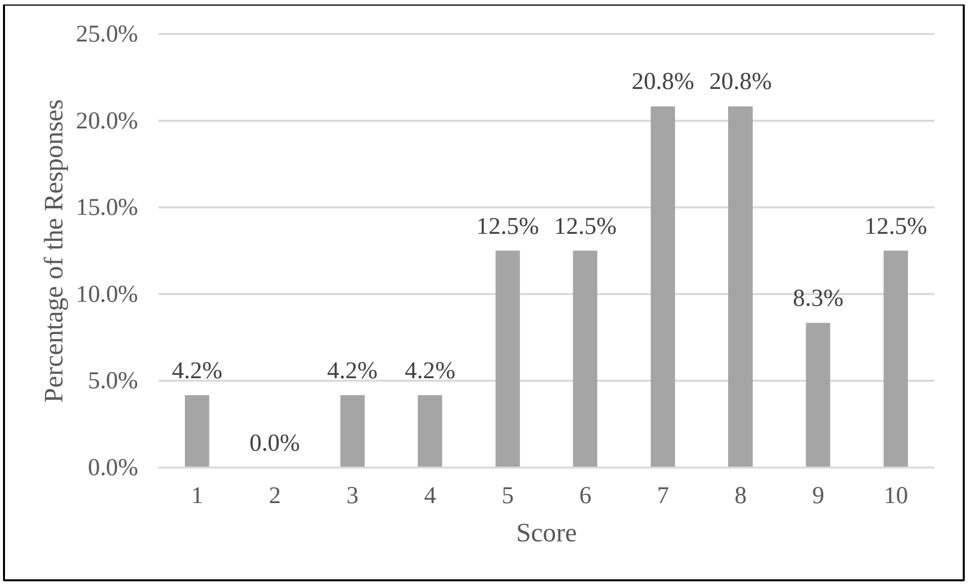

Figure 6: Satisfaction of governmental involvement during the 2004 IOT aftermath

Discussion

The results of the study conducted in the Dikwella DS Division revealed several significant barriers that prevent the division from attaining satisfactory resilience in terms of livelihood restoration, emergency response and infrastructure capacity after the 2004 IOT. The lack of exposure and awareness of modern technology is a major gap. The administration process has also disregarded indigenous knowledge regarding EW mechanisms such as monitoring of animal behavior patterns prior to the occurrence of disasters.

There is a major drawback in evacuation planning and the interest and participation of citizens in disaster drills and training programs are low. Specific planning for more vulnerable community members such as those with special needs is missing. The residents in the area revealed a lack of knowledge regarding the impact of coastal disasters on aspects such as income methods and critical infrastructure. The available evacuation centers have insufficient capacity and facilities. Also, the construction of potential evacuation centers such as schools and governmental organizations being done in low-land areas reduces the safety of such buildings in the case of a disaster. As mentioned in the section showing the study results obtained regarding the effective use of technology in DRR, lack of faith, knowledge, and understanding in EW systems, exist in the community. The available EW towers also showcase a capacity inadequacy in reaching all citizens in the area.

The identified barriers have interdependencies and stakeholders (NCDM, Local Government, Community, Media, MET, DMC) who have direct and indirect influence and responsibilities over addressing them. Figure 7 has been developed to illustrate this phenomenon in a systematic way. A major focus was revealed from a recent research study that specially focused on people with special needs (Jayasooriya et al., 2019). This has denoted the lack of preparedness and lack of special mechanisms towards the evacuation of this sector of the population in a coastal community. Further, the barriers in the existing DRR mechanisms linked to EW in Sri Lanka were identified through previous studies (Hippola et al., 2019). These factors should also be addressed in order to facilitate a better mechanism.

Several barriers in the administrative process of DRR have been identified through this research study as well. There is a lack of policy and a defined process in linking external organizations to the DRR process. This has led to disorganized provision support from various organizations such as coordination of the media-driven support with the local government processes. The documentation process in the aftermath of the previous disaster had taken a long time, making life even more difficult for the disaster victims. The processes and policies do not facilitate community empowerment, and as such, the community has failed to fulfill the disaster recovery stage. There is a questionable level of authority in the defined administrative process. This has been made evident by the constructions along the coastline in the disaster aftermath, which has been done disregarding the non-construction zoning policies implemented by the government in those areas.When constructively observing these barriers, four major attributes can be identified.

a. Not all existing barriers are tangible
b. There is a repetition of the same gap in various context
c. The main responsible authority or stakeholder of barriers can vary or remains the same
d. Some barriers are a result of cascading of another gap

Figure 7 shows the process barrier network developed. Community, Media, NCDM, Local Government, DMC and Department of Meteorology (MET) were the identified elements/institutions that have major links with the barriers identified from the study. It illustrates the cascading nature of every gap and how each of the intuitions is linked with the barriers. It can be used to identify the stakeholders in order to address the barriers. The use of this process will be valuable in all levels of decision making. A gap prioritizing and clustering or ranking can be done using this network diagram methodology.

Often, a disaster caused by natural hazards has the propensity to escalate to disaster level due to existing political and economic conditions in the area [81]. Therefore, in order to minimize future damage and increase resilience, it is imperative that both the administration and community work together to establish a prepared and knowledgeable community.

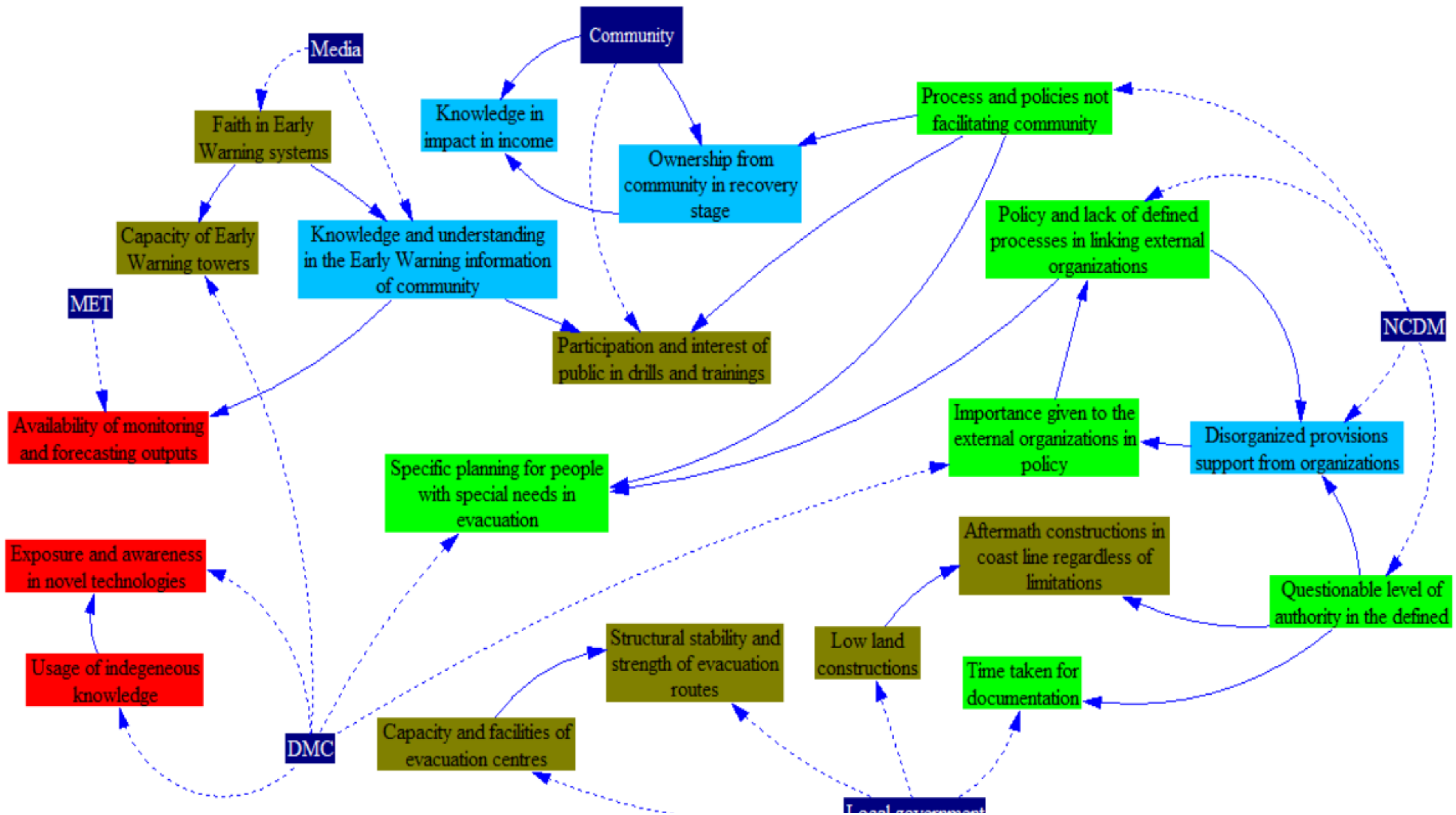

Figure 7: Barrier network

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Disclaimer

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Evaluation of Multi-Hazard Early Warning Systems (MHEWS): Case studies in Myanmar, and Sri Lanka

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Abstract. This paper is based on data collected from the 2004 Tsunami disaster event and analyses the availability of Early Warning Systems in Sri Lanka and Myanmar after 15 years. An evaluation framework in the form of questionnaire survey was developed through a thorough literature review and studying the existing frameworks of both countries. Same questionnaire survey was used to gather information from two communities in Myanmar and Sri Lanka each to understand the existing MHEWS and preferred warning systems. Subject experts were interviewed to verify the information gathered. When analysing the data, an index was developed with parameters of accessibility and preference. The early warning systems were indexed and further analysed in both countries in a comparative manner. The observations indicate the use of early warning towers is very efficient in Sri Lanka whereas TV/Radio has a higher efficiency as early warning system in Myanmar. There are gaps observed in the disaster management mechanism of Sri Lanka and Myanmar during the survey. Specifically in the early warning systems there were gaps identified in terms of technology usage, coverage as well as trust and reliability of warning dissemination which required resource allocation and development.

1. Introduction

According to the United States Geological survey, the world’s fourth largest quake since 1900, impacted Southern Asia on 26th December 2004 unleashing a tsunami that crashed into India, Indonesia, Malaysia, the Maldives, Myanmar, Somalia, Sri Lanka, Thailand, Bangladesh, South Africa, Madagascar, Kenya, Tanzania and the Seychelles. The earthquake had a recorded magnitude of 9.1, origin at coast of Northern Sumatra (3.295°N 95.982°E) with a depth of 30km on December 26th, [1].

After the disaster on 2004, affected countries started investing and developing on Disaster Risk Reduction activities. Early warning is an important part of the DRR activities, where the casualty numbers and damages could have been much lower if proper early warnings were issued. With this understanding the developments on early warning systems were implemented. The developments on early warning systems are not only limited on to Tsunami. The systems are evolved in to multi hazard early warning systems. The paper compares the early warning methods available and the people preference over those early warning methods. The early warning systems development, data accessibility as well as the cultural context, coastal population vulnerability context are found to be of similar and comparable in Sri Lanka and Myanmar. Hence Sri Lanka and Myanmar are two country case studies used where the data were gathered from a scientific research work conducted.

Sri Lanka and Myanmar consists of masculine, collectivist culture [2]. This indicates the behaviour of everyone taking responsibility for each other in the community as well as the dependency of a leader to drive in situations. Theravada Buddhism drives and impacts highly on the cultural attributes in Sri Lanka and Myanmar. Also a high power distance is observed in both countries [3]. This governance level behaviour impacts on the disaster management mechanism in both countries.

Natural hazard maps of Sri Lanka and Myanmar and Sri Lanka has similar readings. Where floods, Cyclones and Droughts are natural hazards present. The highly impacted disaster common for both the countries is the 2004 Tsunami. The coastal regions of Sri Lanka and Myanmar are most vulnerable to natural hazards. Because coasts are amongst the most dynamic environments on Earth. The coastal population regions in Sri Lanka and Myanmar have a history of adapting to environmental change and local sea-level rise.[4]

Myanmar has a total population of 59,094,870 where the coastal population is 1,544,000 [5]. The country has total coastline of 1930 Km [6]. Sri Lanka has a total population of 21,336,833 with a coastal population of 4,355,000 [5]. The island has a total coastal length of 1340 Km [6].

Until 2004 Sri Lanka had very little experience on Tsunamis. According to the historical records the only known is the historical legend of Princess Viharamaha Devi sacrificed to the sea to prevent inundation of the land by sea probably due to a tsunami event in 200 BC [7]. It was after the 2004 Tsunami Sri Lanka implemented policies and started working on the technologies related to Tsunami early warning and risk reduction activities [8].

In Sri Lanka the 2004 tsunami struck a relatively thin but long coastal area stretching over 1,000 kilometers, or two thirds of the country's coastline. [9] There were 13391 deaths and 699 were missing people were recorded in Sri Lanka. From 25 Districts in Sri Lanka, 9 districts had casualties. [10].

When it comes to Myanmar, during the known history Myanmar had experience Tsunami in 1714, 1750, 1930 and in 2004 [11]. The impact data from 1930 and 2004 were only publically available. The deaths recorded from the 1930 and 2004 incidents are 500 and 150 respectively. [12]. At Myanmar there were 22 majorly affected localities from the 2004 Tsunami situated in Ayeyarwaddy Delta, Dawei Area, Myeik Area, and Kawthaung Area. [13]

In Sri Lanka and Myanmar there were number of changes made to the disaster management mechanism after the 2004 Tsunami. In Sri Lanka the Disaster Management Center is the focal point in disaster management whereas National Council for Disaster Management act as the emergency governing body where the president of the country act as the chairman. When it comes to Myanmar there are twelve working committees to govern the disaster management process.[14], [15], [16] Where each of the administrative level has working committees. These were observed during the institutional survey conducted parallel to the community survey as mentioned in the methodology of this paper.

With improvements in the disaster management mechanisms, there were developments in the early warning systems as well in both countries. Even though it was since more than a decade to the date the developments need to be evaluated with respect to the effectiveness in order to be better prepared. This paper identifies the community level early warning mechanism usage and recommend on areas to improve.

2. Methodology

In order to gather data case studies were conducted as research surveys. The agenda and basic framework of the research surveys conducted at Sri Lanka and Myanmar were similar. The Programme was conducted at two selected communities from each country. In Sri Lanka it was Wattegama South and Dodampahala East division of Dickwella, Matara (Figure 1). The communities are located in the southern part of the country with fishing is the common income method. In Myanmar it was Bu Gwe Gyi Village and Thazin Village, in Pathein District (Figure 2). The two communities are surrounded by fishery and prawn farms.

The data were collected using a survey framework developed to evaluate the effectiveness and efficiency of a disaster management mechanism. The survey was constructed on three stages; disaster risk reduction stage, emergency response stage and recovery stage. For each stage there were facts and for each fact tangible attributes were defined in evaluating [17]. At each community the data collection had two parts.

First part of the data collection was from a target group discussion. Government official responsible for the community coordinated the discussion. The target group profiles were elderly people from the community and community leaders whom had the experience of the tsunami event and were part of the disaster management mechanism in community level. The discussions had the objective of understanding the mechanism of disaster management process. Second part of the data collection was the individual survey. The survey team visited the affected community houses under the guidance from community leaders and collected data

Figure 1: Matara District of Sri Lanka

Figure 2: Pathein District of Myanmar

At Sri Lanka 41 responses (All of them were affected from 2004 Tsunami, where 55% were fishermen, 28% were farmers and 17% were others) were recorded and at Myanmar 39 responses (Where 42% were farmers, 39 % were fishermen and 19% were others are the profiles of the respondents.) were recorded.

3. General Observations

Availability of different early warning systems in each country (Availability was observed) was accessed from literature and previous data available.

Large number of early warning methods were checked for the availability of the MHEWs. From those it was identified that there are 5 early warning systems available in Sri Lanka and Myanmar. The National position papers prepared for Sri Lanka and

Myanmar for were referred in identifying the availability and accessibility at each country.

- o Loud Speakers (Where announcements were made using a loud speaker attached to a moving around vehicle)
- o SMS
- o TV/Radio
- o Door to Door
- o Early Warning Towers

These five identified early warning systems are considered for the data observation and analysis in the research work.

Three aspects related to multi hazard early warning were focused and observed during the community surveys at the four community survey sessions.

- General annotations with regard to the early warning systems and related cultural and institutional behaviors.
- Early warning methods community has access to. (Hereon mentioned as the **"**A**ccessibility"**)
- Early warning methods community most likely to respond as per their own preference. (Hereon mentioned as the B **"Preference"**)

General annotations in Sri Lanka

- The Early warning towers had a maximum range of 5km. Hence people living outside of the range could not hear the warning sounds. This was experienced during the evacuation drills.
- Mobile networks do not work properly during cyclones. Hence mobile and internet related warnings do not get disseminated at the time of need.
- TV/Radio signals are not clear during the cyclones and other extreme weather events. Hence community finds it hard to access these modes.
- People had experience on false warnings. Some were generated from community itself. And there was an experience on false Tsunami warning once. Hence community gets reluctant to evacuate during an early warning. [18]
- Community has limited ownership in the disaster management mechanism. [19]

General annotations in Myanmar

- The community has minimum access to electricity. The only available electricity source is from domestic solar panels. Hence the access to TV/Radio and mobile phones is minimum.
- Community has experienced number of false alarms. Even though there are strict regulations to stop such alarms, especially as word of mouth from the community has generated false alarms.
- In the upstream there is a repetition of work from Department of Meteorology and Hydrology and Emergency Operations center of Department of Disaster Management in monitoring, forecasting and disseminating warnings.

During the surveys the respondents were asked to choose all the methods they can receive early warning. Figure 3 illustrates the data comparatively for Sri Lanka and

Myanmar. Percentage number illustrates out of all the respondents how many had chosen that early warning method as one of the ways they can receive early warning.

Sri Lanka and Myanmar do have access to loud speaker systems mostly. It is observed that the early warning towers in Myanmar are not developed to the extent of Sri Lanka. Also Myanmar has accessibility to TV/Radio in a similar extent as Sri Lanka, yet it is not reliable given the gap that Myanmar needs development in electricity in communities.

The next data observation is on the preference of the early warning method. The respondents were asked to rate the warning mechanism they are most likely to respond to. A scale of 0 to 5 was used. The figure 4 illustrates the data collected. Total points for a method was divided by the number of respondents to lean the data.

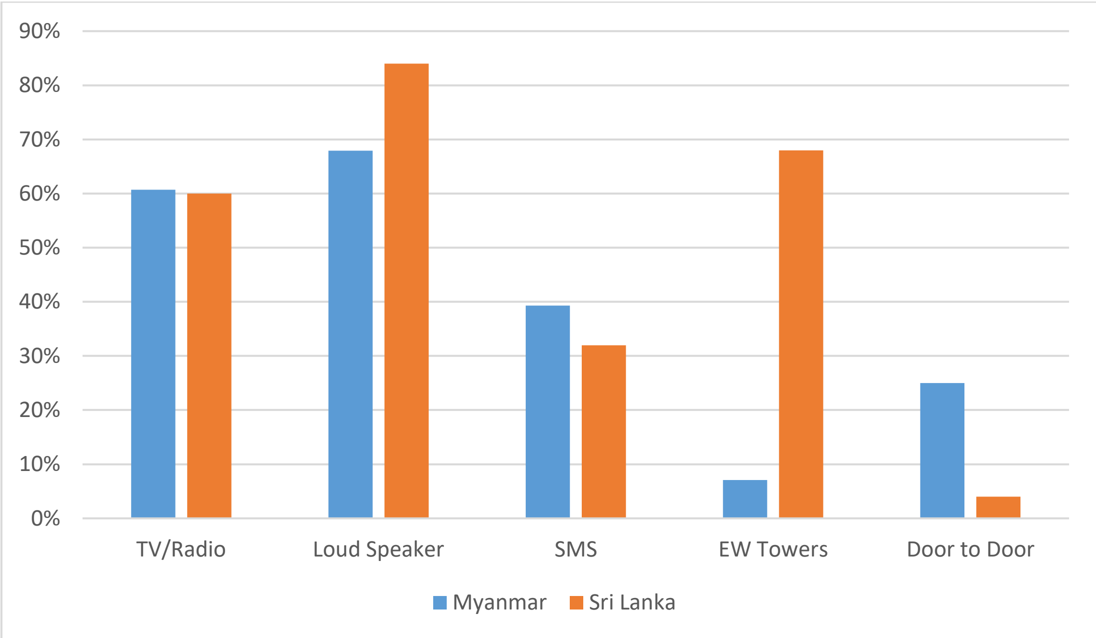

Figure 3: The methods early warning received in Sri Lanka and Myanmar (**"Accessibility"**)

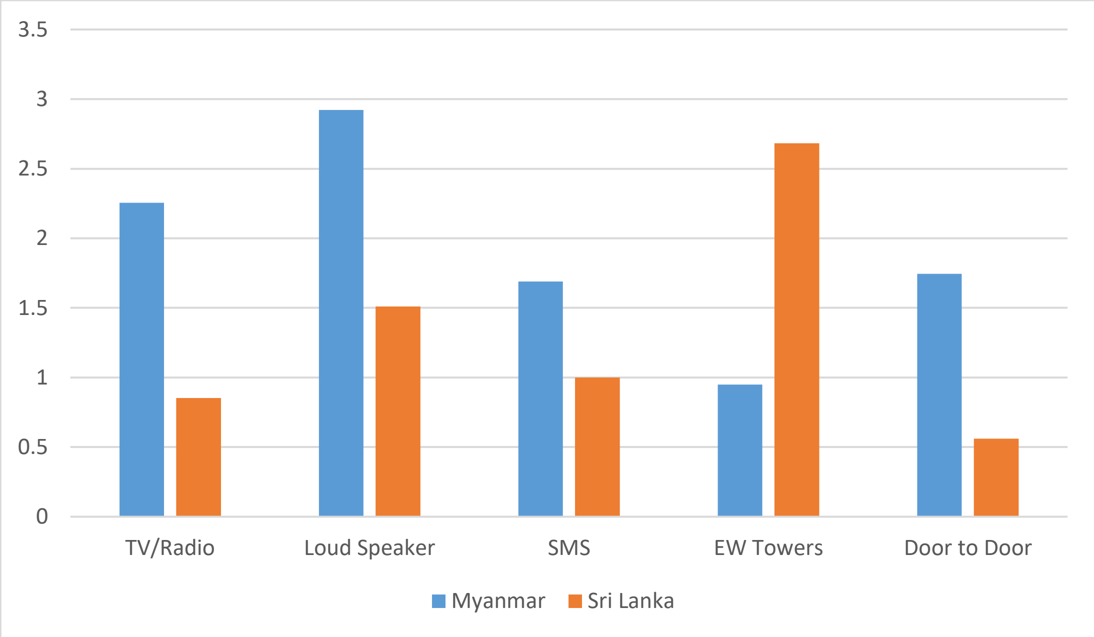

Figure 4: Preference of Early Warning methods in Sri Lanka and Myanmar (**“Preference”**)

Early warning towers has the highest preference in Sri Lanka, where as in Myanmar it is the loud speaker. Door to Door method has a higher preference in Myanmar comparatively.

There are number of gaps observed during the survey. A list down of the identified gaps is provided following section. In the analysis and conclusion the impact from these gaps are too considered.

4. Analysis

For the analysis of Early warning systems an index named EWI – Early Warning Index, for each early warning method was developed as follows.

EWI = Accessibility Percentage of the Early Warning Method x Preference Points

This index indicates the effectiveness and efficiency of an early warning system. The preference and accessibility parameters are the base of the index. Both the parameters are necessary in evaluating an early warning system. Yet they aren’t individually sufficient enough to evaluate. The development of the EWI as well as identifying other parameters can be conducted as an extension of the study.

Table 1: Early Warning Systems index comparison of Sir Lanka and Myanmar

Early Warning Method	Sri Lanka			Myanmar		
	Accessibility	Preference	Index	Accessibility	Preference	Index
TV/Radio	60%	0.85	**0.51**	61%	2.26	**1.38**
Loud Speaker	84%	1.51	**1.27**	68%	2.92	**1.11**
SMS	32%	1	**0.32**	39%	1.69	**0.66**

EW Towers	68%	2.69	**1.83**	7%	0.95	**0.07**
Door to Door	4%	0.56	**0.02**	25%	1.74	**0.44**

In Sri Lanka Loud Speaker and EW towers has indexes over 1. In Myanmar TV/Radio and Loud speaker has indexes over 1. Hence in both countries the loud speakers (A vehicle with a loud speaker on top moving around decimating warnings) has similar and high impact.

With the gaps observed previously it is analyzed that the top indexed Early warning systems has associated barriers in both countries. In Sri Lanka EW towers has the highest index of 1.83. Yet it was observed that the EW towers has a range barrier. The recorded accessibility of 68% was during drills. Which indicates that one third of the community do not heard the warning from EW tower even during the drill. Hence even though people highly preferred (2.69 preference index where the immediate next is 1.51 points with Loud Speaker) practically EW towers has improvements to be made.

Moreover in Myanmar it is TV/Radio has the highest index of 1.38. Yet as discussed in the gaps the communities has barriers in accessing electricity. The recorded 61% of TV/Radio accessibility is from the electricity generated from domestic solar panels. Hence, the reliability of the method is questionable.

Also comparing the index differences for early warning systems EW towers has the highest difference. In Sri Lanka it is 1.83 and in Myanmar it is 0.07. With the 2004 Tsunami experience Sri Lanka has actively made efforts in establishing early warning towers when compares to that of Myanmar. Myanmar do need to further establish early warning towers and develop to improve the accessibility.

The door to door warning dissemination has the lowest index in Sri Lanka with 0.02. Yet in Myanmar it is 0.44. This increment in the door to door method is due to the community ownership in the process of early warning. As mentioned in the gaps Sri Lankan disaster management mechanism has limited coordination with indigenous methods and community owned disaster management mechanisms. In Myanmar the context is completely different where the community has total ownership of the process.

Out of the five early warning systems SMS has lower indexes in both countries, 0.32 in Sri Lanka and 0.66 in Myanmar. The community trust and the reliability of the SMS systems can further improved in both the countries.

5. Conclusion and Areas to Improve

Since 2004 Tsunami event Sri Lanka and Myanmar has made developments in Early warning systems. As this research paper identifies the community preferred early warning systems are required to be identified and further improved to enhance the effectiveness of early warning.

Loud speakers are identified as a major impactful and effective early warning system in both the countries. Hence resource allocation to the loud speaker method as coordination plans for the system is required. A standard operational procedure for the loud speaker method should be made available in each community level and also constant training, drills and practical usage should be tested frequently.

EW towers in Sri Lanka needs to be further improved. An engineering solution is required to improve the range of towers. As well as more towers can be placed in expanding the range. A technological sharing of such systems within the region and outside the region will be helpful for both Sri Lanka and Myanmar in updating EW towers.

SMS, TV/Radio methods has direct warning dissemination from the upstream agencies to the grass root level individuals. Hence improving the trust and reliability of these methods will prepare the communities better in evacuation and disaster response. The network barrier and signal barrier are two major gaps in improving the systems. Further technical research work shall be conducted to find solutions.

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Framework to Evaluate Institutional Relations In Disaster Management Mechanisms

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ABSTRACT

Disaster Management mechanisms are made up with various elements. Governing bodies, Monitoring institutions, Warning disseminations institutions, External organizations, volunteers, affected community are some of the common elements in a disaster management mechanism. The mechanism uses different level of contribution from each of the element in succeeding a disaster. These elements do have different roles and different levels of interest in involving. Hence, the disaster management mechanism gets in to a complicated system. It is a need to get the maximum use of each element given that each of these elements are resources in disaster risk reduction mechanism. The understanding of the relations among each of the element is a necessity in disaster risk reduction activities planning and executing. Humans and Institutions are major components in such mechanisms. This paper evaluates the behaviour of these two components using case studies from Sri Lanka, Myanmar and Maldives. Institutions from Disaster Management mechanism of each country is compared in the behavioural patterns. Level of interactions with other institutions, level of interactions with humans, level of power delegation and boundary of work are criteria used in comparing. The founded results were then used to validate a human – institutional behaviour framework.

INTRODUCTION

The 2004 Tsunami was an eye opener in to disaster management topic in most of the affected countries. 2004 Tsunami resulted over 230,000 deaths across more than 15 countries across Asia to Africa. [6] The earthquake had a recorded magnitude of 9.1, origin at coast of Northern Sumatra (3.295°N 95.982°E) with a depth of 30km on December 26th, [89].

Among the countries affected this research paper is based on Sri Lanka, Myanmar and Maldives. Sri Lanka do have a total coast line length of 1340 Km and a coastal population of 4,355,000. In Myanmar it's 1930 Km and 1,554,000 whereas in Maldives it is 1129 Km and 532,668 people [91]. These countries do have a collectivist culture, a high power distance, and same level of masculinity as cultural similarities.[14] With these similar attributes the research work is focused around Sri Lanka, Myanmar and Maldives.

Tsunami disaster in 2004 was a breakthrough event in disaster management where there were number of policies and frameworks planned, empowered and implemented by responsible governing bodies to successfully mitigate, reduce risk, and to manage the disaster risk. [100] These policies empower, create and set the scope for number of institutions to carry out the disaster management tasks. An important aspect in institutional implementation is the coordination, networking among these institutions. The level of these correlations defines the total effectiveness in overall effectiveness of disaster management mechanism [52].

All the institutions involved in disaster management mechanism have a vital role. Also the methods and involvement of each organization is categorically unique and has its own correlation mechanisms and levels. It is important to understand the correlation behaviour of these institutions. Given these facts the identification of the categorical systematic relations of the institutions is a necessity to understand the overall effectiveness of disaster management mechanism.

This paper identifies the overall institutional involvement in disaster management mechanism in Sri Lanka, Maldives and Myanmar. Then propose a framework to identify the correlative mechanism of each of the institution.

7 Methodology

The data presented in this paper are collected from surveys and interviews conducted at Sri Lanka, Myanmar and Maldives. A questionnaire survey was build up in assessing the disaster management mechanisms [53]. The survey was carried out in two segments, an institutional survey and a community survey. Institutional survey was conducted with key stakeholder institutions in each country with the objective of identifying the disaster management mechanism and understanding the role of each stakeholder. Whereas Community survey was conducted to understand the reality of practice in policies and framework in the grass root level and to identify the gaps in the mechanism.

The identified institutions were then sorted in risk management framework in a comparative manner for Sri Lanka, Myanmar and Maldives as presented in the next section of this paper. With that identification of the institutions the framework to evaluate the correlative and systematic relationships of institutions was then developed.

8 Institutional Arrangements in Disaster Management Mechanisms

Institutional survey conducted and the country specific disaster management policies were referred to extract and identify the institutions available in each country [32], [105], [106].

The identified institutions are categorized under planning for disaster risk, disaster risk monitoring and disaster treatment as illustrated in the tables. The category titles are compromised from risk management process literature available. Planning for disaster risk involves the establishment of risk context (disaster management policy planning), risk identification (disaster and hazard mapping), risk pre-treatment (disaster risk reduction) activities. The institutions listed under that category are empowered and established institutions in each country to carry out and conduct such work. Disaster risk monitoring activities involve the early warning related institutions of each country. Similarly the disaster treatment related institutions are whom responsible and empowered to carry out emergency response and recovery of a disaster.

The following are the compiled institutions empowered and established from the policies in Sri Lanka, Myanmar and Maldives. The institutions are illustrated in a categorized manner according to the risk processes as mentioned above.

1.1 Institutions empowered and provisioned for Disaster Management in Sri Lanka

Table 1: Institutions provisioned for Disaster risk planning

Planning for Disaster Risk	Operational Level
National Council for Disaster Management	National
Ministry of Disaster Management	National
Disaster Management Center	National /Local
Ministry of Defense	National
Ministry of Health	National
Other line ministries	National

Table 2: Institutions provisioned for Disaster risk monitoring

Disaster Risk Monitoring	Operational Level
Department of Meteorology	National / International
Department of Irrigation	National
National Building Research Organization	National
National Aquatic Resources Research and Development Agency	National
Marine Environment Protection Authority	National
Geological Survey and Mines Bureau	National

Table 3: Institutions provisioned for disaster treatment

Disaster Treatment	Operational Level
National Disaster Relief Services Center	National / Local
Provincial Councils	Local
District Secretariat Offices	Local
Divisional Secretariat Offices	Local

1.2 Institutions empowered and provisioned for Disaster Management in Myanmar

Table 4: Institutions provisioned for Disaster risk planning

Planning for Disaster Risk	Operational Level
National natural Disaster Management Central Committee	National
State Working Committees	National
Ministry of Home Affairs	National
Ministry of Social Welfare, Relief and Resettlement Department	National
Ministry of Health	National
Department of Disaster Management	National
Asian Disaster Reduction Center	International
ASEAN Committee on Disaster Management	International

Table 5: Institutions provisioned for Disaster risk monitoring

Disaster Risk Monitoring	Operational Level
Department of Meteorology and Hydrology	National / International

Table 6: Institutions provisioned for Disaster treatment

Disaster Treatment	Operational Level
Relief and Resettlement Department	National
Emergency Operation Centre	National
District Working Committees	Local
Township Working Committees	Local
Village Working Committees	Local
Armed forces of Myanmar	National / Local

1.3 Institutions empowered and provisioned for Disaster Management in Maldives

Table 7: Institutions provisioned for Disaster risk planning

Planning for Disaster Risk	Operational Level
National Steering Committee	National
National Disaster Management Authority	National
DRR Unit	National
Corporate affairs unit	National

Table 8: Institutions provisioned for Disaster risk monitoring

Disaster Risk Monitoring	Operational Level
Meteorology Department	National / International

Table 9: Institutions provisioned for Disaster treatment

Disaster Treatment	Operational Level
National Emergency Operations Center	National / Local
National Emergency Response forces	National / Local
Maldives National Defense Forces	National / Local
Atoll DM units	Local
City DM units	Local
Island DM units	Local

Table 1, Table 4 and Table 7 illustrates institutions empowered by policies in Sri Lanka, Myanmar and Maldives respectively to plan for disaster risk. Table 2, Table 5 and Table 8 illustrates the risk monitoring institutions identified from policies available for risk monitoring in above countries respectively. Whereas Table 3, Table 6, and Table 9 illustrates institutions empowered to conduct disaster treatment activities in each country.

With this understanding on institutions on disaster management mechanism of each country the framework to evaluate the correlations of institutions was developed.

9 Outline of the evaluation framework

There are mainly two parts of relations analyzed and focused on to understand the behavior of institutions in a disaster management mechanism. Given that disaster management mechanisms are compromised with institutions and people, the two parts of relationships are inter institutional (I-I) relations and human – institutional (H-I) relations as illustrated in the figure 1.

Institutional relations	
Institutional - Institutional relations (I-I)	Institutional - Human relations (I-H)

Figure 1: Institutional relations

Under each section there are criteria's formed to access the level of the correlation. Once an institution is evaluated under all the criteria's institution can be mapped to compare and cluster. The evaluation framework does not score and evaluate the institutions in most important to least important but cluster the institutions according to the levels of interactions they have.

1.4 Institutional – Institutional relations

There are five criteria's proposed in identifying the "I - I" correlations as illustrated in the table 10.

Table 10 I –I Criteria

Criteria No.	Criteria	Response
1.1	Interaction requirement with organizations higher in the power rank	Positive/Negative
1.2	Interaction requirement with organizations lower in the power rank	Positive/Negative
1.3	Interaction requirement with internal organizations in DMM	Positive/Negative
1.4	Interaction requirement with external organizations in DMM	Positive/Negative
1.5	Number of total interactive organizations	Cumulative Number

Power rank is the organizational hierarchy of the country and disaster management mechanisms. There are organizational charts available in Sri Lanka, Myanmar and Maldives which can be used in this criteria [52]. Internal and external institutions are defined as according to the system of disaster management mechanism. Whereas institutions which aren't part of the system during the undisturbed stage of the system are external institutions and institutions which are in the system during the undisturbed stage are internal institutions.

In policy definitions there are provisions made to create the coordination among institutions. Institutions do need to coordinate with other organizations who are having higher authority level, to take the guidelines and direct orders, and pass them as actions or messages to the fellow institutions. These behaviors are evaluated in the criteria 1.1 and 1.2.

In system (community and disaster management) the provisions are provided on mainly on interactions among the internal institutions. Hence the approaches taken by institutions in interacting with institutions internal and external are different. This behavior is evaluated in the criteria 1.3 and 1.4.

Also in the network the total points in the loop are defined the communication criticality of an institution. This is measured in the criteria 1.5.

Criteria 1.1, 1.2, 1.3, and 1.4 has a direct one zero answer. The positive answer gains 1 point and negative answer gains 0 point. There are in middle (fractional) points for those four criteria's.

Whereas in the criteria 1.5 gains fractional point. Maximum gaining is 1 and minimum is 0. The calculation of this point is based on comparison of institutions. The institution with most number of interactive organizations get the highest point and the institution with the least number of interactive organizations gets minimum point. Other organizations gets in between points as proportional to the two benchmarks (The highest and the lowest).

1.5 Institutional – Human Relations

There are four criteria's proposed in identifying the "I - H" correlations as illustrated in Table 11.

Table 21 I – H Criteria

Criteria No.	Criteria	Response
2.1	Top most interaction point in people hierarchy	1-10
2.2	Bottom most interaction point in people hierarchy	1-10
2.3	Percentage number of people directly interacts with	Percentage
2.4	Percentage number of people indirectly interacts with	Percentage

People hierarchy is the pillar of peoples as mentioned in the literature: Lessons Learned from Interventions of External Organizations In Disaster Management: Case Study of Floods in Kalutara, Sri Lanka [53]. The pillar is of a cone as illustrated in the figure 2. The power of people is varying along the vertical axis.

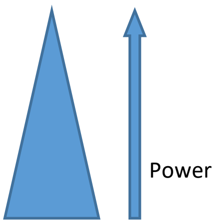

Figure 2: People hierarchy

Direct involvement defined here is the people who can directly communicate with the institution. This includes the people who are working to the institution as well. The people who involves in direct discussions with the institution, people who have veto power over the institution, people who receives communications (messages, orders, guiding etc.) directly from the institution and people who directly send communications (messages, updates, etc.) to the institutions compromised the people who directly interacts with institution.

Indirect involvement is people who has impacts on actions of the institution yet do not communicate directly with the institution. These people gets the benefit out of the actions yet has minimum capability in defining the actions of the institution.

Institutions are governed by people who are in different layers of people hierarchy for different institutions. This behavior of institutions and people are measured in the criteria 2.1 and 2.2. The beneficial party of the institutional activities are the people of the community. Yet the way of beneficial is completely depend on the institutional activity nature decisions. That is measured in the criteria 2.3 and 2.4.

Criteria 2.1 and 2.2 has a combined point range from 0 to 2, including fractions. The difference of criteria 2.1 and 2.2 in compared to the total people hierarchy defines the amount of points gained by an institution. For an example if an institution has the top most interaction point as the top most position of the people hierarchy and the bottom most point as the bottom point of the people hierarchy then the institution has a 100% range hence gains total points, two.

In criteria 2.3 and 2.4 the percentage is calculated as a portion of the total population of the country. Each criteria has a point range from 1 to 0 including fractions. 100% equals to 1 and 0% equals to 0.

1.6 Institutional Map

With the data generated as per the above mentioned framework for each country a graph was produced. The "I – I" data used as the Y axis and "H – I" as the X axis.

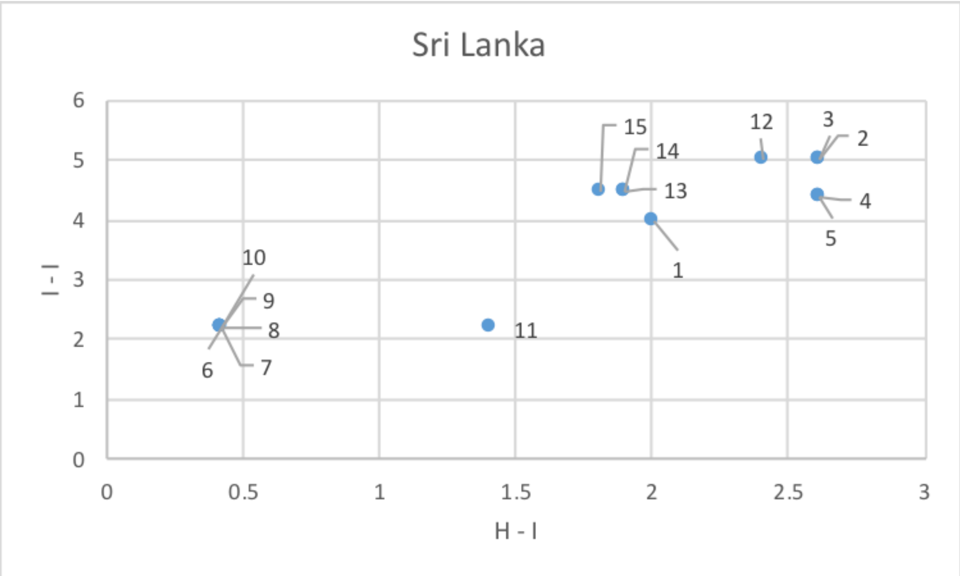

Figure 3: Institutional Map of Sri Lanka

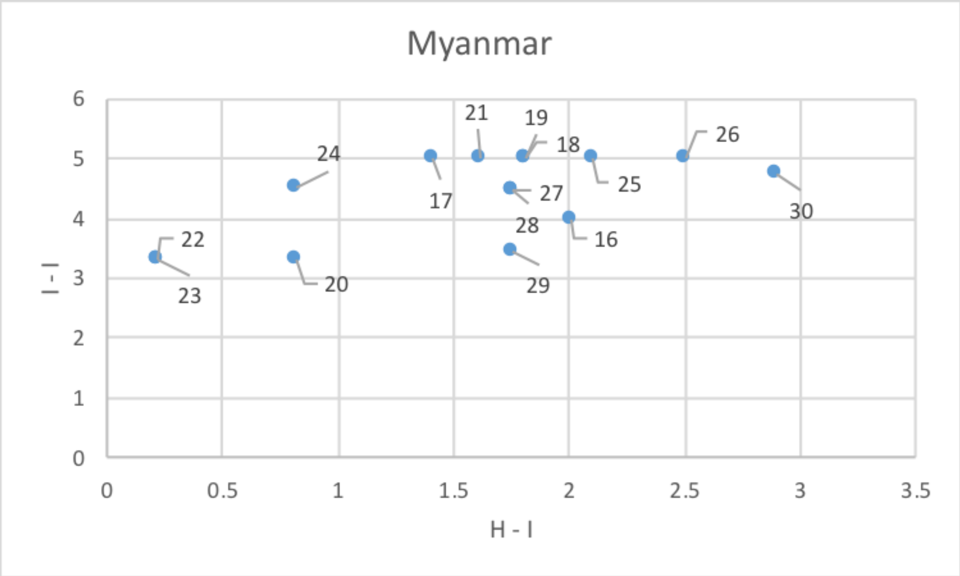

Figure 4: Institutional Map of Myanmar

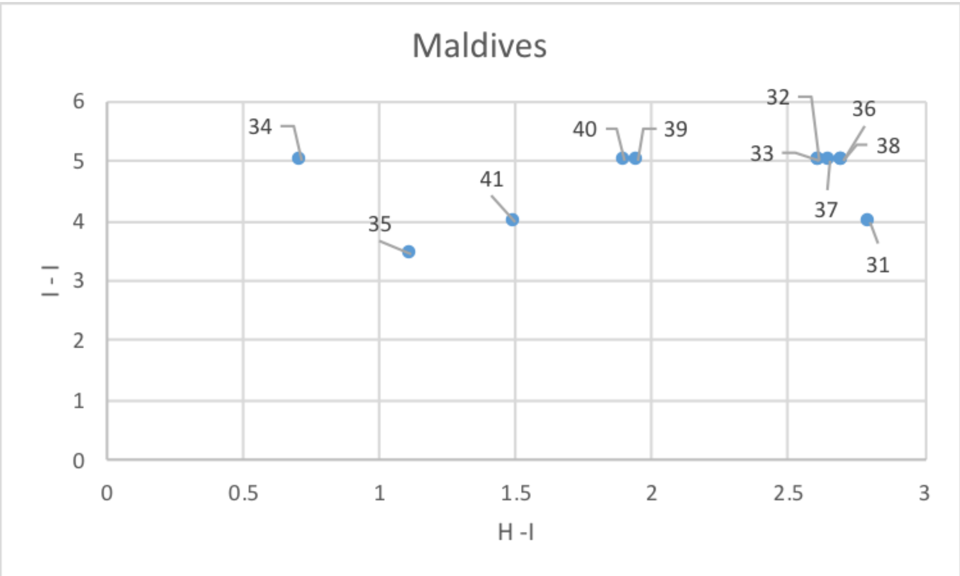

Figure 5: Institutional Map of Maldives

For Figure 3, 4 and 5 following is the legend, Figure 6.

No	Institution	No	Institution	No	Institution
1	National Council for Disaster Management	16	National natural Disaster Management Central Committee	31	National Steering Committee
2	Ministry of Disaster Management	17	State Working Committees	32	National Disaster Management Authority
3	Disaster Management Center	18	Ministry of Home Affairs	33	DRR Unit
4	Ministry of Defence	19	Ministry of Social Welfare, Relief and Resettlement Department	34	Corporate affairs unit
5	Ministry of Health	20	Ministry of Health	35	Meteorology Department
6	Department of Meteorology	21	Department of Disaster Management	36	National Emergency Operations Center
7	Department of Irrigation	22	Asian Disaster Reduction Center	37	National Emergency Response forces
8	National Building Research Organization	23	ASEAN Committee on Disaster Management	38	Maldives National Defence Forces
9	National Aquatic Resources Research and Development Agency	24	Department of Meteorology and Hydrology	39	Atoll DM units
10	Marine Environment Protection Authority	25	Relief and Resettlement Department	40	City DM units
11	Geological Survey and Mines Bureau	26	Emergency Operation Centre	41	Island DM units
12	National Disaster Relief Services Center	27	District Working Committees		
13	Provincial Councils	28	Township Working Committees		
14	District Secretariat Offices	29	Village Working Committees		
15	Divisional Secretariat Offices	30	Armed forces of Myanmar		

Figure 6: Legend (Numbering of institutions)

Figure 3 indicates the map of institutions of Sri Lanka whereas Figure 4 and Figure 5 respectively presents the map of institutions in Myanmar and Maldives.

Above graphs are developed with the limited data available. Hence a specific analysis on the graphical illustrations would not enhance an accurate picture of the data. A detailed presentation of the use of the developed method and framework is discussed in the following section.

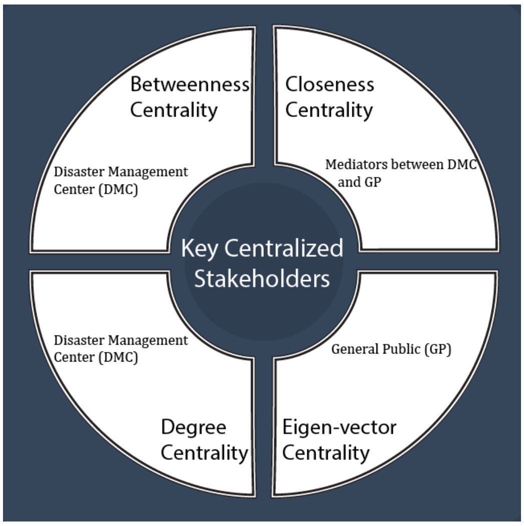

Figure 7: Stakeholder behaviour of Disaster Management

Figure 7 (Source: [43]) is from a research conducted using the Social Network Analysis. This identifies the stakeholder behavior of Disaster Management. Overall policies and institutional structures indicates the centralized umbrella behavior of the disaster management framework of Sri Lanka. When compared with the results of this research work, it is identical that the disaster management mechanisms of Myanmar and Maldives has the centralized umbrella behavior.

10 discussion

The method can be used to tier and cluster the institutions in disaster management mechanisms to evaluate the institutions with respect to the correlations. The clustering can easily point out the gaps and areas to improve while the related decisions can be generalized accordingly.

The comparing mechanism enhances the illustration of institutional priorities and critical natures. Hence it is possible to understand the solutions for each institutions and look for options to repeat the same solution.

There are number of patterns identifiable from the graphs produced. It is evident that the top most bodies and has similar positioning (Need to verify with further data) whereas the risk monitoring related institution/s are having different positioning. Likewise there can be patterns identified and further analysis on these patterns is another extension of study.

When allocating resources for institutions with the understanding of which institution is critical in correlations specific experts and extra resources allocation can be done in much logical pattern.

The framework can be further expanded with further criteria. The given criteria too can be further strengthen in order to capture the best illustration of institutions. The framework is to be improved with more data and validation is an extension of the research study

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