Randeniya, M., Palliyaguru, R. and Amaratunga, D., 2022. Defining critical infrastructure for Sri Lanka. In: Sandanayake, Y.G., Gunatilake, S. and Waidyasekara, K.G.A.S. (eds). *Proceedings of the 10th World Construction Symposium*, 24-26 June 2022, Sri Lanka. [Online]. pp. 313-325. DOI: https://doi.org/10.31705/WCS.2022.26. Available from: https://ciobwcs.com/2022-papers/

DEFINING CRITICAL INFRASTRUCTURE FOR SRI LANKA

Maheshi Randeniya[1], Roshani Palliyaguru[2] and Dilanthi Amaratunga[3]

ABSTRACT

In the last few decades, infrastructure has played a major role in supporting modern society. Moreover, there has been an increase in natural and human-induced disasters worldwide. In these situations, securing infrastructure is a major requirement. Confusion and misinformation can result if the boundaries of what constitutes critical infrastructure for a country are not clearly defined. Identification of critical infrastructure is the first step in the process of securing and protecting the available critical assets. This study aims to establish the infrastructure that can be classified as "critical infrastructure" in Sri Lanka. This includes establishing a clear margin for subsectors that fall within and operate within critical infrastructure and, consequently, ascertaining a clear definition for the critical infrastructure of the nation.

This study adopted a mixed-method approach, which included an initial comprehensive literature analysis on infrastructure and the parameters involved in determining the criticality of infrastructure. Secondly, a questionnaire and semi-structured interviews were conducted to determine which infrastructure sectors would be most critical to Sri Lanka. The most significant infrastructures with the parameters of national security, economic sustainability, quality of life, public health, and safety, the criticality of infrastructure were ranked in both pre- and post-disaster scenarios, and an appropriate margin for the Sri Lankan critical infrastructure was demonstrated. The emergency services sector was found to have the most significant infrastructure in both pre- and post-disaster situations. Accordingly, the study reveals emergency services, water, energy, transportation, telecommunication, and finance as the critical infrastructures for Sri Lanka.

Keywords: *Criticality of Infrastructure; Infrastructure; Parameters of Criticality; Pre- and Post-Disaster.*

1. INTRODUCTION

The quality of a nation's infrastructure is one of the foundations of its rate of growth and the living standards of its people. Infrastructure strengthens and drives the economy, creates jobs, and acts as a key enabler for future economic development and rising living standards across the whole country (Peerenboom, et al., 2001). In general, the term "infrastructure" refers to the sufficiency of a country's public works. However, the term "Critical Infrastructure" can be broadly defined as the systems, assets, facilities, and networks that provide essential services and are necessary for the national security,

[1] M.Sc. Candidate, University of Peradeniya, Kandy, Sri Lanka. maheshirandeniya1@gmail.com
[2] Senior Lecturer, University of Vocational Technology, Ratmalana, Sri Lanka. rpalliyaguru@uovt.ac.lk
[3] Professor, University of Huddersfield, UK, d.amaratunga@hud.ac.lk

economic security, prosperity, and health and safety of their respective nations (New Zealand Treasury, 2014).

They ensure important social functions. Access to and availability of critical infrastructure varies from country to country. In Sri Lanka, none of the ruling governments in history so far has been able to specify which infrastructure could be considered critical, as opposed to countries such as Canada, the USA, the United Kingdom, and Australia, which have clearly specified infrastructure that is "critical" and further their sub-areas too. Failure or destruction of that infrastructure has severe effects on the health, security, or economic and social wellbeing of the population or the functioning of governmental institutions (Critical Infrastructure - CIPedia, 2022.).

Moreover, in the last few decades, there has been an alarming increase in natural and human-induced disasters worldwide. Most of these disasters affect infrastructure and cause chaos. A minor damage can be a cause of a catastrophic danger to a country. With all these glaringly dangerous situations, securing infrastructure has been a critical requirement. Identification of critical infrastructure is the first step in the process of securing and protecting the available critical assets. Thus, having a definite idea of the critical infrastructure can ensure our nation's security. Therefore, this article aims to establish the infrastructure that can be classified as "critical infrastructure" in Sri Lanka.

It involves establishing a clear margin within which critical infrastructures can operate and, consequently, ascertaining a clear definition for the critical infrastructure of the nation.

2. LITERATURE REVIEW

2.1 OVERVIEW OF CRITICAL INFRASTRUCTURES

Modern society heavily depends upon critical infrastructure networks that cater to essential services (Puuska, et al., 2018). There are numerous definitions of the term "critical infrastructure". All these definitions ultimately describe assets that provide resources or services that have a compelling impact on societal functions (Lewis and Petit, 2019). According to Wiley (2021), "critical infrastructure" is a body of systems, networks, and assets that are essential to the continued operation of a nation, its economy, and public health and safety. Critical infrastructure systems can comprise an array of services such as water, wastewater, telecommunications, power, and transportation (road, rail, airport, port) (Brown, et al., 2017).

Nevertheless, when exploring extant literature and government publications, it is evident that Sri Lanka has been unable to define its critical infrastructure yet. Regulation of critical infrastructure is essential in every country to develop legal governance regimes. According to Harašta (2018), without clearly defined boundaries on what constitutes critical infrastructure at the national level, the focus on protecting the infrastructures would be burdensome and incomplete. Further, defining critical infrastructures is vital to a nation because it alters the responsibility and management of public funds and the method of identifying the infrastructures (Harašta, 2018). In Sri Lanka, the Essential Public Services Act. No 61 of 1979 has stated that in the event of a disaster, any service which would be named as essential at that time would be considered as critical for that particular time period. This may lead to a risk of the criticality of a particular

infrastructure being misinterpreted for political advantage, mismanagement of public funds, etc. Thus, the country is vulnerable to exploitation.

Furthermore, defining the boundaries of critical infrastructure is another critical but difficult task, mainly because of the interdependencies of infrastructure. Infrastructure interdependency can be defined as a bidirectional relationship between two assets in which the operations of both assets affect each other (Lewis and Petit, 2019). According to Peerenboom, et al. (2001), interdependencies can be differentiated into four classes based on natural resource transit between the systems and by the level of interactions as physical, geographic, logical, and cyber interdependencies. So, the boundaries are difficult to define in some cases.

2.2 COUNTRIES WITH RECOGNIZED CRITICAL INFRASTRUCTURES

Different countries have recognized critical infrastructure suitable for their needs and contexts. For example, the US government has identified seventeen critical infrastructures, namely: agriculture and food, water, public health, emergency services, government, defence, information and telecommunications, banking and finance, energy, transportation, chemical industry and hazardous materials, postal and shipping, national monuments and icons, and critical manufacturing etc (Harašta, 2018). In Canada, ten critical infrastructures have been identified as critical, namely, energy and utilities, communication and information technology, finance, health care, food, water, transportation, safety, government, and manufacturing (Malalgoda and Amaratunga, 2015). Table 1 illustrates a comparison of the recognized critical infrastructures of four countries.

Table 1: Critical infrastructure sectors and the countries

Infrastructure Sectors	Countries			
	A	**B**	**C**	**D**
Water Sector	√	√	√	√
Transportation Sector	√	√	√	√
Energy Sector	√	√	√	√
Telecommunication Sector	√	√	√	√
Finance Sector	√	√	√	√
Armed Forces	√	√	√	
Health Sector	√	√	√	√
Manufacturing Sector	√	√		
Chemical Sector		√	√	
National Monuments		√		
Canada, B-USA, C-United Kingdom, D-Australia				

As per Table 1, water, transportation, energy, telecommunication, finance, health, and armed forces sectors were considered critical by almost all four countries. The infrastructure common to these four countries was used as the basis for the questionnaire and the interview. Furthermore, out of the 17 sectors in the USA, only the sectors that are directly relevant to Sri Lanka were taken into consideration in this research. This is

because, as a developing nation, some of the sectors are not relevant to Sri Lanka (e.g., nuclear reactors, materials and waste sector).

2.3 PARAMETERS USED IN RECOGNIZING CRITICAL INFRASTRUCTURE

It is essential that clear boundaries are set when defining critical infrastructure for which various parameters are used by other countries. Table 2 illustrates a comparison of those parameters used by other countries. Definitions of critical infrastructure from both developed and developing countries have been considered in the preparation of Table 2.

Table 2: Parameters used to define critical infrastructure

Respective Countries/Organizations	Parameters						
	A	**B**	**C**	**D**	**E**	**F**	**G**
European Union	√	√	√	√			
NATO (North Atlantic Treaty Organization)	√	√	√	√	√	√	
Australia	√	√	√				
Austria	√	√	√	√			
Belgium	√	√	√	√			
Brazil	√	√	√				
Canada	√	√	√	√			
Germany	√	√		√			
United Kingdom	√	√	√	√			
New Zealand		√		√			√
Ethiopia		√		√			
India	√	√		√		√	
Pakistan	√	√		√			

A-Economic Sustainability, B- National Security, C- Quality of life, D- Public Health and safety, E- Environment, F- Effective functioning of the government, G-Fundamental Rights

Table 2 demonstrates that four parameters, namely, economic sustainability, national security, quality of life, and public health and safety, are commonly adopted by almost all the countries/organisations listed in the table. Here, "economic sustainability" stands for the practice of aiding long-term economic growth without any unfavourable impact on the social, cultural, and environmental aspects of the community (Economic Sustainability, 2015) According to the (United Nations, 2022), "national security" is the security and defence of a sovereign state, including its citizens, economy, and institutions. Quality of life, which, according to the World Health Organization., 2022, is a measure of happiness that varies according to the personal preferences of the citizens. And finally, "public health and safety" is about protecting and improving the health of people and their communities (CDC Foundation, 2022). Nevertheless, it is interesting to note that countries such as Germany, New Zealand, Ethiopia, India, and Pakistan have not considered the parameter called "quality of life" in their definitions of infrastructure. It is an indication that those particular countries do not consider the quality and happiness of their citizens as critical; instead, they consider national security and public health and safety more critical.

3. METHODOLOGY

3.1 DATA COLLECTION

Initially, a comprehensive literature synthesis on the importance of infrastructure for Sri Lanka and the parameters involved in determining the criticality of infrastructure was carried out. Secondly, the mixed-method approach was adopted for the collection of empirical data. It consisted of: (1) a questionnaire survey in order to determine the significance of the infrastructures with reference to the selected four parameters, which can be ultimately used to define critical infrastructures; and (2) ten semi-structured interviews among the professionals attached to the chosen five infrastructure sectors with an experience of over twenty years. Interviewees were selected through the purposive sampling technique, ensuring the selected interviewees have an in-depth knowledge of the functions of the relevant infrastructure sector and the legal and policy background of them.

In the questionnaire, the respondents were asked to rate the significance of various infrastructures with reference to four parameters that define the "criticality" (i.e., national security, economic sustainability, quality of life, public health, and safety) on a five-point Likert scale that extends from 1 (being very less significant) to 5 (being highly significant). The four parameters were selected as per Table 2, which are recognized to be commonly adopted by almost all the countries/organizations listed in the table in defining their critical infrastructure. The questionnaire mainly consisted of two parts: the first part refers to the significance of infrastructure during the normal situation (i.e., before a disaster), whereas the second part refers to the significance following a disaster. Each included six major infrastructure sectors and several sub-sectors under each, totalling 23 sub-sectors. The sectors for the questionnaire survey were determined from the literature review as indicated in Table 1, which have already been recognized as critical infrastructures in other countries.

When it came to identifying the infrastructure, it was decided to forgo manufacturing, chemicals, and national monuments because Sri Lanka does not have a thriving chemical or national industry that would cripple the nation. The USA has identified the above sectors as critical because its economy is mostly based on them. As for monuments, the USA has several monuments with great economic and historical value for the nation. (i.e., the Abraham Lincoln Statue, Lady Liberty, etc.). Accordingly, the infrastructure that would be most suitable for our nation was chosen, namely, water, energy, telecommunication, transportation, essential services, and financial infrastructure. The questionnaire was distributed among 109 built environment and other related professionals associated with various infrastructure sectors in Sri Lanka who had adequate knowledge to provide informed opinions about the nation's infrastructure. The total number of responses (70) received out of 109 questionnaires dispatched indicates a response ratio of 64%. Before the original questionnaire was sent, a pilot study was conducted to determine whether the questionnaire was designed appropriately. The reliability of the questionnaire was analysed, and the Cronbach's Alpha was determined to be in the range of (0.953 to 0.798), which exceeds the threshold value of 0.7, indicating that the questionnaire was reliable and consistent.

3.2 DATA ANALYSIS

The questionnaire was analysed using descriptive statistics techniques, which are used to describe the characteristics of a data set. The use of these techniques enabled the identification of the relative importance of the chosen infrastructure. The Relative Importance Indexes (RII) of infrastructure against the stated parameters were calculated using MS Excel as per Eq. 01 (Khaleel and Nassar, 2018).

$$RII = \Sigma(Wn)/A \times n \qquad Eq.\ 01$$

Where, W = Constant expressing weight given to each response, A = Highest weighting, n = Frequency of responses = Total number of responses

In determining the level of "criticality", it was considered that the most significant infrastructures have an RII score of above 0.800, as per Khaleel and Nassar's (2018) following five expressions, which are defended at equal intervals:

0.1≤ little effect (LE) < 0 .2, 0.2 ≤some effect (SE)< 0.4, 0.4 ≤ average effect (AE) <0.6, 0.6 ≤ high effect (HE)< 0.8 ,0.8 ≤very high significances (VHE) ≤ 1.0

The semi-structured interviews were analysed using the manual content analysis method with reference to the themes identified from the questionnaire survey to further solidify its findings and finally to determine which infrastructure sectors and sub-sectors would be the most critical for Sri Lanka.

4. RESEARCH FINDINGS AND DISCUSSION

4.1 PRE-DISASTER SIGNIFICANCE OF INFRASTRUCTURE

As indicated in Table 3, four subsectors out of the twenty-three scored an overall RII of more than 0.800, which suggests that they are of very high significance. Among these, two are related to the emergency sector, which are law enforcement infrastructure (police, military) (0.819) and fire and emergency services infrastructure, including health services (0.808). Moteff, et al., (2003) suggest that emergency infrastructure reduces the threat to life or property and cannot be established at a moment's notice. The other two are related to the telecommunications sector, which are internet (deep sea cable) infrastructure (0.827) and postal and shipping infrastructure (0.814). The majority of the infrastructures in the 21st century is dependent on information systems, so a disruption in information can cause a ripple effect that would in turn lead to serious consequences that affect the performance, security, and reliability of those infrastructures (Alcaraz and Zeadally, 2015). As for all the other subsectors, their significance was found to be high where the overall RII scores remained above 0.6, but none of the subsectors of water, transport, finance, or energy can be classified as of very high significance. As far as the sector RIIs are concerned, the energy sector has remained as the least significant infrastructure among the selected infrastructures, even though it has an RII score above 0.6 and is a vital input in economic growth because there is a close link between the availability of energy and the growth of a nation (Bridge, et al., 2018)

Also, the analysis suggests that the emergency services subsectors have very high significance when it comes to national security (0.903, 0.848, 0.846), quality of life (0.806) and public health and safety (0.800, 0.846, 0.811). The finance sector has very high significance in terms of economic sustainability (0.891, 0.803) and quality of life

(0.843). As for the water sector, it was analysed to be of very high significance in quality of life (0.863, 0.803, 0.8499) and public health and safety (0.849, 0.809, 0.860). The telecommunication sector was analysed to be of very high significance in all four parameters: economic sustainability (0.803, 0.840), national security (0.866, 0.837), quality of life (0.811, 0.837) and public health and safety (0.829). The transportation sector shows a RII score of 0.831 in national security, 0.9, 0.863, 0.894, 0.806 in economic sustainability, and 0.826 in quality of life, suggesting that its significance degree is very high. Finally, the energy sector has a very high significance in quality of life (0.814, 0.811) and the rest of the infrastructure subsectors were classified as "high" except for the water (sewerage system: 0.597), telecommunication (telephone: 0.586) and energy (wind powerplant: 0.586), which are classified as of "average" significance in relation to the national security parameter. Even though sewerage systems play an important role in sanitation and disease prevention, they do not directly lead to national security, and also, when just considering wind power plants and telephone services, they do not directly affect national security.

Table 3: Significance of infrastructure during pre-disaster context

Infrastructures	Sub-Sectors					Main Sectors		
	RII Against Parameters							
	National Security	Economic Sustainability	Quality of Life	Public Health and Safety	Overall RII	Sector RII	Rank	Degree of Significance
Emergency Services Sector								
Law Enforcement (Police, Military) infrastructure	0.903	0.76	0.806	0.80	0.811			
Fire and Emergency Services infrastructure including health	0.848	0.76	0.780	0.84	0.808	**0.801**	1	VHE
Public Safety Answering Points (119)	0.846	0.67	0.774	0.81	0.776			
	0.866	**0.73**	**0.787**	**0.81**				
Finance Sector								
Banking infrastructure	0.780	0.89	0.843	0.66	0.794			
Insurance infrastructure	0.703	0.80	0.780	0.77	0.766	**0.780**	2	HE
	0.741	**0.84**	**0.811**	**0.72**				
Water Sector								
Water Supply infrastructure	0.660	0.79	0.863	0.84	0.792			
Irrigation Drainage and Flood Control infrastructure	0.683	0.78	0.803	0.80	0.769	**0.770**	3	HE
Sewerage Systems infrastructure	0.597	0.69	0.849	0.86	0.749			
	0.647	**0.75**	**0.838**	**0.83**				
Telecommunication Sector								
Internet (Deep Sea Cable) infrastructure	0.866	0.80	0.811	0.82	0.827			
Postal and Shipping infrastructure	0.837	0.84	0.837	0.74	0.811			
Internet (Satellite) infrastructure	0.774	0.78	0.749	0.64	0.739	**0.758**	4	HE
Television/Radio infrastructure	0.694	0.79	0.794	0.66	0.737			

Infrastructures	Sub-Sectors					Main Sectors		
	RII Against Parameters							
	National Security	Economic Sustainability	Quality of Life	Public Health and Safety	Overall RII	Sector RII	Rank	Degree of Significance
Telephone infrastructure	0.586	0.78	0.697	0.62	0.674			
	0.751	**0.80**	**0.778**	**0.70**				
Transportation Sector								
Airport infrastructure	0.831	0.90	0.769	0.69	0.798			
Road infrastructure	0.649	0.86	0.826	0.74	0.769			
Harbour infrastructure	0.791	0.89	0.723	0.66	0.768			
Railway infrastructure	0.649	0.80	0.780	0.67	0.727	**0.750**	5	HE
Underground Pipeline infrastructure	0.660	0.72	0.706	0.66	0.686			
	0.716	**0.83**	**0.761**	**0.68**				
Energy Sector								
Hydro Powerplant infrastructure	0.749	0.68	0.814	0.68	0.734			
Solar Powerplant infrastructure	0.737	0.66	0.811	0.62	0.709			
Thermal Powerplant infrastructure	0.683	0.62	0.746	0.66	0.679	**0.699**	6	HE
Wind Powerplant infrastructure	0.586	0.78	0.697	0.62	0.674			
	0.689	**0.69**	**0.767**	**0.65**				

4.2 POST-DISASTER SIGNIFICANCE OF INFRASTRUCTURE

As per Table 4, five subsectors out of twenty-three have scored an overall RII of more than 0.800, which suggests that they are of "very high significance." Among these, three are related to the emergency sector: law enforcement infrastructure (police, military) (0.814), fire, public answering points (0.809) and emergency services infrastructure, including health services (0.804). According to Rothery and Branch (2005), there are infrastructures that rely on the availability of other types of infrastructure, and emergency services is one of those infrastructures that would benefit other infrastructure sectors. Another "very high" significance is related to the telecommunications sector, which is the disaster warning system (0.821). The public's reliance on warning systems for protection in a post-disaster situation would be the result of this score. The other is related to the transportation sector, which is road infrastructure (0.814). This result suggests the dependence of the transportation sector on relief aid, emergency care, protection, and on-time deliveries in a post-disaster situation. As for all the other infrastructure subsectors, their significance is found to be "high," where the RII scores remained above 0.6. None of the subsectors of finance and energy can be classified as of high significance.

According to the analysis, the emergency services subsectors have very high significance in terms of national security (0.840, 0.846, 0.854), quality of life (0.803), and public health and safety (0.814, 0.809, 0.804). As for the water sector, it is found to be of very high significance in quality of life (0.800, 0.811, 0.829) and public health and safety (0.811, 0.806, 0.820). The telecommunication sector is found to be of very high significance in terms of national security (0.843 and 0.814), quality of life (0.820 and 0.806) and public health and safety (0.821). The transportation sector has an RII score of

0.803 in national security, 0.823 and 0.809 in economic sustainability, suggesting that its significance is very high. The rest of the infrastructure is classified as "high." The energy sector is still the least significant with an RII of (0.680, 0.752, 0.699, 0.659) but still with "high" significance.

As for the sector rankings, the one with the most significance is the emergency services sector (0.809), whereas the rest of the infrastructures are identified as having "high" significance (water: 0.782, telecommunication: 0.765, finance: 0.758, transportation: 0.754, energy: 0.698). The energy sector has remained the least significant infrastructure among the selected infrastructures. It might be due to energy not being an immediate aftermath need. Food, water, medicine, and shelter are considered basic needs in the event of a disaster.

Table 4: Significance infrastructure during the post-disaster context

Infrastructures	Sub Sectors					Main Sectors		
	RII Against Parameters							
	National Security	Economic Sustainability	Quality of Life	Public Health and Safety	Overall RII	Sector RII	Rank	Degree of effect
Emergency Services Sector								
Fire and Emergency Services	0.84	0.78	0.80	0.83	0.814			
Public Safety Answering Points (119)	0.84	0.73	0.78	0.81	0.809	**0.809**	1	VHE
Law Enforcement (Police, Military)	0.85	0.76	0.79	0.80	0.804			
	0.847	**0.762**	**0.792**	**0.817**				
Water Sector								
Water Supply infrastructure	0.76	0.79	0.80	0.81	0.792			
Irrigation Drainage and Flood Control	0.73	0.79	0.81	0.80	0.786			
Sewerage Systems infrastructure	0.697	0.723	0.829	0.820	0.767	**0.782**	2	HE
	0.730	**0.771**	**0.813**	**0.812**				
Telecommunication Sector								
Disaster warning system	0.843	0.797	0.820	0.826	0.821			
Telephone infrastructure	0.789	0.797	0.806	0.746	0.784			
Internet (Satellite)	0.814	0.803	0.771	0.740	0.782			
Television/Radio infrastructure	0.757	0.760	0.754	0.737	0.752	**0.765**	3	HE
Internet (Deep Sea Cable) infrastructure	0.780	0.774	0.729	0.686	0.742			
Postal and shipping infrastructure	0.70	0.77	0.71	0.64	0.709			
	0.781	**0.784**	**0.766**	**0.730**				
Finance Sector								
Insurance infrastructure	0.711	0.806	0.774	0.677	0.742			
Banking infrastructure	0.75	0.76	0.80	0.77	0.774	**0.758**	4	HE
	0.734	**0.787**	**0.787**	**0.724**				
Transportation Sector								
Road infrastructure	0.803	0.823	0.826	0.803	0.814		5	HE
Airport infrastructure	0.794	0.809	0.766	0.714	0.771	**0.754**		

Infrastructures	Sub Sectors					Main Sectors		
	RII Against Parameters							
	National Security	Economic Sustainability	Quality of Life	Public Health and Safety	Overall RII	Sector RII	Rank	Degree of effect
Harbour infrastructure	0.786	0.794	0.720	0.694	0.749			
Railway infrastructure	0.720	0.769	0.751	0.711	0.738			
Underground Pipeline infrastructure	0.680	0.723	0.706	0.691	0.700			
	0.757	**0.783**	**0.754**	**0.723**				
Energy Sector								
Hydro Powerplant infrastructure	0.723	0.786	0.740	0.669	0.729			
Solar Powerplant infrastructure	0.669	0.749	0.697	0.677	0.698			
Thermal Powerplant infrastructure	0.689	0.737	0.689	0.640	0.689	**0.698**	6	HE
Wind Powerplant infrastructure	0.640	0.737	0.671	0.649	0.674			
	0.680	**0.752**	**0.699**	**0.659**				

4.3 COMPARISON OF SIGNIFICANCE OF INFRASTRUCTURE BETWEEN PRE- AND POST-DISASTER CONTEXTS

There has been an increase in natural and human-induced disasters worldwide. Sri Lanka's inability to define critical infrastructure has left the nation behind in terms of enhancing its infrastructure stock. The purpose of considering both pre- and post-disaster contexts for this research was to show that in day-to-day life, regulation of critical infrastructure is essential to develop legal governance regimes, and without clearly defined boundaries on what constitutes critical infrastructure at a national level, the focus on protecting the infrastructure would be incomplete. In the case of a disaster, identifying which infrastructures are critical would be necessary to provide vital community and individual functions. Also, to be protected and remain operational during a disaster situation.

As per Table 3, the most significant infrastructure in both pre-and post-disaster is found to be the emergency services sector (0.801 and 0.809, respectively). The results prove that the emergency sector is not something that can be established overnight. Therefore, its significance cannot be overlooked during normal conditions. In the pre-disaster context, the sector RIIs appear in descending order from emergency services sector (0.801), telecommunications (0.758), water (0.770), transportation (0.750) and energy (0.699) when compared to the post-disaster context, where the order follows from the emergency services sector (0.809), water (0.782), telecommunication (0.765), finance (0.758), transportation (0.754) to the energy sector (0.698). The post-disaster scenario has resulted in an increased level of significance in every infrastructure sector except in the energy and finance sectors. The reason for this could be that finance and energy are not immediate post-disaster needs. They would actually come after basic needs like food, shelter, water, and medicine. The significance of the finance sector has gone down by two positions from pre-disaster to post-disaster. The reason for the energy sector's low significance compared to other infrastructure sectors, both in pre- and post-disaster, could be the public's failure to realise the significance of the energy sector until they suffer

from a complete failure of it. As far as the current situation (from February 2022 to date) in Sri Lanka is concerned, the nation's restlessness due to the current power crisis alone could be enough to imagine how significant the energy sector is. As this questionnaire survey was conducted in December 2021, none of the respondents were concerned about the level of significance of energy infrastructure and the potential fallout from an energy crisis.

One respondent stated that "*In Sri Lanka under the emergency law, critical infrastructure has been identified",* but upon further research, it was found that the emergency law does not state any infrastructures as critical, but it states the personnel who has the power to name the particular infrastructure as critical in the face of a disaster. Interviewees also confirmed that the non-existence of a definition for critical infrastructure in Sri Lanka, whereas each respective sector has its own internal protective measures taken even though they are not stipulated in the respective Acts. For example, hydro dams can only be accessed through an army base. In this case, as per the interview respondents, the energy sector's significance to national security, economic stability, and public health and safety has been acknowledged and considered. Nevertheless, infrastructure interdependency has made setting up parameters against which to define the criticality of infrastructure difficult due to the interconnectivity of its functions. In other words, for the functionality of one sector, another sector's output would be important. In this context, even though there are Acts such as the National Water Supply & Drainage Board Act, the Ceylon Electricity Board Act, the Road Development Authority Act, the Telecommunication Act, and the Essential Public Services Act, and policies for infrastructure, the governing bodies of the infrastructure sectors in Sri Lanka have a blurred understanding of their remits of work due to the lack of defined critical infrastructure.

5. CONCLUSIONS

Critical infrastructure could be defined as a "system of identifiable sectors whose destruction or incapacity would have an enervative impact on the economic sustainability, public health and safety, quality of life, and national security of a country." The study proposes suitable "critical infrastructures" for Sri Lanka while identifying the respective parameters against which they are considered to be significant (critical). As per the literature review, four parameters were recognized as applicable to Sri Lanka: national security; economic sustainability; quality of life; and public health and safety. The aim of the study was achieved through a questionnaire and semi-structured interviews. Among the 6 infrastructures, the 4 parameters identified through the literature survey were analysed with the RII values determined for one infrastructure exceeding 0.800, namely the emergency services sector, which was in turn identified as "very high" in significance, and the other five infrastructures as "high" in significance in both pre- and post-disaster contexts. The findings prove the importance of emergency services and other infrastructure in both situations.

Accordingly, the study reveals emergency services, water, energy, finance, transportation, and telecommunication as the critical infrastructure for Sri Lanka. The remits of these sectors are that the essential services sector includes any service provided by the armed forces, health, and fire; as for the water sector, any service concerning sanitation, irrigation, drainage, flood control, and water supply; the energy sector to include the generation of power; and the telecommunication sector to include every means of telecommunication, including telephone, internet, television, radio, and postal

services; transportation to include every service under transportation by air, land, and sea; and finance to include its services concerning management of money through investing, borrowing, lending, saving, forecasting, and budgeting.

The primary outcome of this study is the identification of critical infrastructure for Sri Lanka. Thus, the study findings can be used as a reference when conducting further studies on critical infrastructure, for example, defining the boundaries of critical infrastructure, realizing and analysing interdependencies between critical infrastructure, and determining protection measures for critical infrastructure.

6. REFERENCES

Alcaraz, C. and Zeadally, S., 2015. Critical infrastructure protection: requirements and challenges for the 21st century. *International Journal of Critical Infrastructure Protection*, 8, pp. 53-66.

Anon., 2022. *Critical Infrastructure - CIPedia*. [Online] Available from: https://websites.fraunhofer.de/CIPedia/index.php/Critical_Infrastructure#Australia [Accessed 3 March 2022].

Anon., 2021. *Critical Infrastructure,* Wiley Telecom books, IEEE Xplore. [Online] Available from: https://ieeexplore.ieee.org/abstract/document/9415356 [Accessed 9 March 2022].

Anon., 2015. *Economic Sustainability - Office of Sustainability*. [Online] Available from: https://sustainability.umw.edu/areas-of-sustainability/economic-sustainability/ [Accessed 11 March 2022].

Anon., 1979. *Essential Public Services* - LawNet. [Online] Available from: https://www.lawnet.gov.lk/essential-public-services-4/ [Accessed 24 May 2022].

Anon., 2022. *National Security versus Global Security,* United Nations. [Online] Available from: https://www.un.org/en/chronicle/article/national-security-versus-global-security [Accessed 24 May 2022].

Anon., 2022. *What is Public Health?,* CDC Foundation. [Online] Available from: https://www.cdcfoundation.org/what-public-health [Accessed 24 May 2022].

Anon., 2022. *WHOQOL - Measuring Quality of Life,* The World Health Organization. [Online] Available from: https://www.who.int/tools/whoqol [Accessed 24 May 2022].

Bridge, G., Özkaynak, B. and Turhan, E., 2018. Energy research and social science energy infrastructure and the fate of the nation: Introduction to special issue. *Energy Research & Social Science*, 41, pp. 1-11.

Brown, C., Seville, E. and Vargo, J., 2017. Measuring the organizational resilience of critical infrastructure providers: a New Zealand case study. *International Journal of Critical Infrastructure Protection*, 18, pp. 37-49.

Harašta, J., 2018. Legally critical: Defining critical infrastructure in an interconnected world. *International Journal of Critical Infrastructure Protection*, 21, pp. 47-56.

Khaleel, T. and Nassar, Y., 2018. Identification and analysis of factors affecting labour productivity in Iraq. *MATEC Web of Conferences*, 162, pp. 1-11.

Lewis, L.P. and Petit, F., 2019. Critical infrastructure interdependency analysis: Operationalising resilience strategies. pp. 1-33. [Online] Available from: https://www.unisdr.org/files/66506_f415finallewisandpetitcriticalinfra.pdf.

Malalgoda, C and Amaratunga, D., 2015. A disaster resilient built environment in urban cities: The need to empower local governments. *International Journal of Disaster Resilience in the Built Environment*, 6(1), pp. 102-116.

Moteff, J., Copeland, C., Fischer, J., Ave, I. and Washington, S.E., 2003. Report for congress received through the CRS web critical infrastructures : What makes an infrastructure critical ? *Time*, p. 21. [Online] Available from: http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA467306&Location=U2&doc=GetTRDoc.pdf.

New Zealand Treasury, 2014. *Forging a comon understanding for critical infrastructure: Shared narative*. (March). [Online] Available from: http://www.infrastructure.govt.nz/publications/critical5/crit5-narrative-v2.pdf.

Peerenboom, J.P., Rinaldi, S.M. and Kelly, T.K., 2001. Critical Infrastructure interdependencies. *IEEE Control Systems*, 21(6), pp. 11-25.

Puuska, S., Rummukainen, L., Timonen, J., Lääperi, L., Klemetti, M., Oksama, L. and Vankka, J., 2018. Nationwide critical infrastructure monitoring using a common operating picture framework. *International Journal of Critical Infrastructure Protection*, 20, pp. 28-47.

Rothery, M. and Branch, C.I.., 2005. Critical infrastructure protection and the role of emergency services. *The Australian Journal of Emergency Management*, 20(2), pp. 45-50.