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CARGOTECTURE TO MINIMISE PROBLEMS IN POST-DISASTER RECONSTRUCTION PROJECTS IN SRI LANKA

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ABSTRACT

Cargotecture is a sustainable housing solution that has gained popularity in recent years. However, its potential for Post Disaster Reconstruction (PDR) projects has not been fully explored locally and globally. This research aims to develop a framework to overcome the problems in the PDR projects through the implementation of cargotecture in Sri Lanka. A comprehensive literature review synthesises existing research on integrating cargotecture for PDR projects. The research adopted a mixed-method approach. A questionnaire survey was conducted with forty-five construction professionals selected through snowball sampling and data was analysed using RII analysis to identify the critical problems in PDR projects. Then, semi-structured interviews were conducted with ten experts selected through selective sampling. Code-based content analysis was used to identify problems in PDR projects and the benefits of integrating cargotecture for PDR projects. The study revealed 18 problems in PDR Projects, while high time consumption was identified as a significant problem in PDR Projects. Further, the study identified 17 benefits of integrating cargotecture for PDR projects, including reducing construction duration and modularity. The study developed a framework which offers industry practitioners significant insight into the possible use of ISO shipping containers as a sustainable and cost-effective disaster relief housing option. From an academic point of view, the study adds to the current literature on disaster relief housing by investigating the viability of employing ISO shipping containers. The study serves as the foundation for more detailed research on the social and environmental implications of employing shipping containers for disaster relief housing.

Keywords: *Benefits; Cargotecture; ISO Shipping Container; Post-Disaster Reconstruction; Sustainable Housing.*

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1. INTRODUCTION

"Disasters can be defined as an action that causes a threat to life, wellbeing, material goods, and the environment from the extremes of natural processes or technology" (Gunes & Kovel, 2000, p.136). Barenstein et al. (2005) stated that while scientific research on global sensitivity to hazards, risk reduction, and catastrophe resilience is increasing, disasters continue to have serious repercussions, such as fatalities, massive economic losses, and societal upheaval. Disasters have a negative impact on the built environment, resulting in homelessness, widespread population relocation, and higher mortality. Hidayat and Egbu (2010) suggested that Post Disaster Reconstruction (PDR) is restoring the livelihoods of impacted communities by constructing new housing and infrastructure. Disasters have a 20-fold greater impact on the built environment in developing countries than in developed countries (Barakat, 2003), owing to widespread substandard construction, leaving many people in need of housing in countries that are already struggling with their daily economies and housing challenges (Uddin & Matin, 2021).

Hidayat and Egbu (2010) stated that emergency aid, which includes providing food, medical care, and shelter immediately after a disaster, is deemed beneficial, while the reconstruction is often a long-term recovery operation which is slow, expensive, and difficult. Jones (2006) emphasised that PDR may have a permanent influence on a country's development objectives and may be a turning point in the lives of the impacted populations. In Sri Lanka, an investigation by the United Nations Office for Disaster Risk Reduction in 2019 found that 80% of people residing in locations considered to have a high risk of landslides are reluctant to switch from their existing residences (Siriwardhana et al., 2021). Therefore, it is important to be prepared for both disaster situations and PDR. Even though PDR is crucial, earlier studies found several problems. The primary objective of a PDR project is to increase beneficiary satisfaction, yet most projects fall short of this objective as most structures are constructed temporarily rather than permanently (Islam et al., 2018). In contrast to most ordinary construction projects, post-disaster housing projects are more diverse, including social, cultural, and economic requirements, and are also quite dynamic (Alaloul et al., 2019). Le Masurier et al. (2006) stated that because the disasters were on a relatively small scale, there was not much of a difference between the typical building process and the reconstruction procedure overall. In addition, Rotimi et al. (2006) highlighted that it would be difficult to obtain regular resource levels and that there will unavoidably be a lack of skilled individuals to perform impact assessments and consent processes. When natural resources are rare locally, it might be difficult for poorer countries to access resources for post-disaster rehabilitation. Reconstruction efforts following disasters in nations like Indonesia and Sri Lanka are dependent on assistance from outside, including funding from the World Bank and International Non-Governmental Organisations (INGOs) for the importation of labour and supplies (Jayasuriya & McCawley, 2008). Moreover, it is still challenging to create effective communication between resettlement agencies and affected populations (Siriwardhana et al., 2021).

One of the possible alternatives to tackle the problem of slowdown construction of PDR projects is the "shipping container architecture" technique, which uses ISO shipping containers as a building material (Paparella, & Caini, 2022; Radwan, 2015). The reuse of steel shipping containers as a structural element and an architectural envelope that can support a specific purpose or human activity is known as "Cargotecture," which combines the words 'cargo' and 'architecture' (Radwan, 2015). Subsequently, the term "cargotecture" refers to the utilisation of shipping containers in building construction (Al-Khatib et al., 2021). Further, ISO-certified shipping containers are built with identical dimensions to be readily loaded, unloaded, transported, and stacked worldwide (Sun et al.,2017). The ISO shipping container box was created to move trade products from one location to another. These shipping containers are all the same size, allowing easy loading, unloading, transportation, and stacking anywhere around the globe (Wong et al., 2018). Moreover, containerisation is a particularly developed technique for transporting commercial items globally, which is cost-effective (Ling et al., 2020). Furthermore, the use of cargotecture has grown significantly in recent years due to its robust plating, low cost, and ubiquitous availability (Sun et al., 2017). In addition, Shen (2019) stated that cargotecture has various advantages, including lower building costs, faster construction time, and environmental sustainability. There are many types of research have been carried out related to PDR projects in Sri Lanka (Palliyaguru et al., 2008; Gunawardena et al.,2014; Siriwardhana et al.,2021). However, there is a lack of research aiming at the applicability of cargotecture for PDR Projects in Sri Lanka. Therefore, this study aims to provide a significant endeavour in integrating cargotecture for future PDR projects in Sri Lanka. Accordingly, the research aims to develop a framework to overcome the problems in PDR through the benefits of cargotecture in PDR projects in Sri Lanka.

2. LITERATURE REVIEW

2.1 PROBLEMS IN PDR PROJECTS

Following a disaster, reconstruction must address the affected people's contradicting requirements, as well as the need for organisations to develop programmes that address both the immediate need for shelter and the long-term need for permanent housing (Bahmani & Zhang, 2021). Ismail et al. (2014) identified each of the rebuilding activities, which comprise planning, design, purchasing, construction, examination, and completion. Post-disaster restoration operations have particular challenges that extend beyond standard construction issues, and they are prone to creating unsatisfactory building solutions (Siriwardhana et al., 2021). According to Ismail et al. (2014), post-disaster reconstruction projects frequently deal with uncertainty and complexity, with individuals working in disaster-affected region rehabilitation facing the most difficult duties. Safapour et al. (2021) placed the challenges into four categories: general, physical, social, and economic. Table 1 identifies the problems in PDR projects.

Table 1: Problems in PDR projects

No	Problem	References
1	Supply chain dysfunction	[1], [2], [3], [11]
2	Resources shortage	[2], [3], [4]
3	Coordination and communication issues	[2], [3], [4], [5], [6], [10], [11]
4	Infrastructure breakdown	[2]
5	Corruption	[2], [11]
6	Lack of technical and managerial expertise	[5], [10], [11]
7	Lack of guidance	[5], [8], [10]
8	Poor quality of work	[2], [3], [11], [12]
9	Health and safety issues	[3], [12]
10	Political factors	[5], [10], [11]
11	Public policies	[5], [7], [10]

No	Problem	References
12	Financial management	[3], [5], [9], [10], [11], [12]
13	Beneficiary identification and participation	[5], [11]
14	Information and knowledge dissemination	[5], [10]

Source: [1] Celentano et al. (2019), [2] Celentano et al. (2018), [3] Bilau et al. (2017), [4] Alsaadi and Acar (2019), [5] Hidayat (2014), [6] Baarimah et al (2021), [7] Kounnavong et al. (2017), [8] Grimes et al. (2011), [9] Schwartz et al. (2020), [10] Seneviratne (2011), [11] Alaloul et al. (2019), [12] Vahanvati and Mulligan (2017)

According to Table 1, the most identified problems by the authors are coordination and communication issues, financial management, and supply chain dysfunction. Those problems are negatively affecting the speed of the reconstruction process. As a strategy to increase the speed of the reconstruction process, cargotecture technology can be adopted. When it comes to large-scale post-disaster restoration projects, effective delivery has become a major concern (Safapour et al., 2021). According to Alsaadi and Acar (2019), one of the major challenges affecting the success of PDR project performance is the failure to properly manage community cultural continuity while providing development opportunities in PDR projects, resulting in culturally incompatible solutions that are unsustainable in the long run. Celentano et al. (2019) have identified supply chain planning challenges and resource shortages as major bottlenecks in reconstruction projects. Bilau et al. (2017) indicate challenges associated with logistics and supplies as one of the major management issues that arise in large-scale housing reconstruction programmes. Although these circumstances are well known, the strategies required to overcome these difficulties appear to be less clear (Bahmani & Zhang, 2021). The reuse of ISO shipping containers in the construction industry can be innovative and promote a sustainable environment. The provision of ISO container information in an intuitive manner can be convenient for engineers for their design purpose. Such informative data will help to promote container building and thus bring new life to the abandoned shipping container. According to Ling et al. (2020), an ISO shipping container, a standardised steel box used for universal cargo transportation is one of the potential candidates to solve the housing problem. Schwartz (2020) stated that the shipping container is designed to withstand harsh weathering and heavy loading over long-distance transportation, which makes it very durable and suitable for housing purposes. Therefore, it is needed to consider whether the ISO shipping container can be used to overcome the above-mentioned problems in PDR projects.

2.2 BENEFITS OF CARGOTECTURE FOR PDR PROJECTS

Cargotecture provides an affordable way of manufacturing a building module to be repeated, which can reduce the construction cost and time drastically (Amate & Brotas, 2014). Answering the critical issues in the reconstruction process and benefits offered by Cargotecture as a modular housing project can be discussed as follows. Table 2 identifies the benefits of cargotecture for PDR projects.

Table 2: Benefits of Cargotecture for PDR projects

No	Benefits	References
1	Reduce the construction duration	[5], [6], [7], [8], [11], [12], [13], [14], [15]
2	Resource availability and integration	[5], [9], [14]
3	Ability to endure corrosion	[1], [3], [4], [12]
4	High Durability	[1], [3], [4], [12], [14], [15]
5	Economical	[7], [12], [14], [15]
6	Seismic stability	[2], [7], [8]

No	Benefits	References
7	Availability and skills of the workforce	[5], [8], [11]
8	Minimise the involvement of expertise in planning	[5], [7], [8], [11]
9	Overall quality and end-user satisfaction	[5], [7], [11]
10	Promote Sustainability	[1], [4], [10], [11], [12], [13], [14]
11	Reduced site labour requirement	[4], [7], [8], [9]
12	Environmentally less sensitive	[7] [12],
13	Modularity	[2], [11], [12], [13], [14], [15]
14	Transportability	[2], [7], [11], [14], [15]
15	Demountable after use	[2], [10], [11], [13], [14]
16	Low weight	[7], [14]

Source: [1] Ling et al. (2020), [2] Gamón, (2020), [3] Shen et al. (2019), [4] Elrayies (2017), [5] Tas et al. (2010), [6] Weerakoon et al. (2019), [7] Wong et al. (2018), [8] Lawson et al. (2012), [9] Gunawardena et al. (2014b), [10] Gunawardena et al. (2014a), [11] Zafra et al. (2021), [12] Al-Khatib et al. (2021), [13] Sun et al. (2017), [14] Amate and Brotas (2014), [15] Paparella and Caini (2022)

The most identified benefit of the cargotecture for PDR projects is the reduction of the construction duration. According to Wong et al. (2018), in container architecture, the majority of the work is completed off-site (up to 90%, including interior construction), saving time and labour. Further to the authors, the build time of modular construction is typically 50-60% less than traditional onsite construction, and the weight is about 30% of the weight of conventional masonry construction. Steinbach (2022) stated that ports around the world are dealing with a high amount of congestion due to empty shipping containers. Further to the author, the containers have the potential to be repurposed into various types of buildings, such as homes, offices, studios, apartments, schools, dormitories, and emergency shelters. Tas et al. (2010) have identified that 'time' has a much higher rank than the other elements that influence the design of post-disaster permanent housing. Gunawardena et al. (2014) emphasised that the incensement of building supplies prices over time and changes in labour costs over time make the rehabilitation process more expensive than it should have been. According to Zafra et al. (2021), one of the primary characteristics that make modular building a widely wanted new technology is its time efficiency. According to Lawson et al. (2012), many houses can be manufactured at the same time using mass manufacturing facilities, and they can also be put onsite at the same time, reducing construction time. Because of the saved time, the impacted communities would be able to resume their livelihoods considerably sooner.

According to Gunawardena et al. (2014), since a large portion of the modular structure's building process is pre-planned and carried out in a factory environment, even in a post-disaster rebuilding situation, the process of constructing a module from its raw components should not require any major alterations. Further to the authors, because the interiors, façades, roofs, and so on are all pre-built into the modules, the planning required becomes considerably easier. Since the skill required to build a modular housing unit is largely required within the production plant, the site labour requirement can be reduced (Al-Khatib et al., 2021). Further to the authors, when the modules are on site, they will only take a minimal amount of labour to install. Since many home rebuilding procedures are volunteered by local communities, and the knowledge required in the onsite construction of modular houses is little where they can give a better and more efficient service. Since the main resource of cargotecture modules is used shipping containers, the availability of resources is high (Amate & Brotas, 2014). Container buildings have the potential to significantly lessen the burden of resource discovery. According to Paparella and Caini (2022), the benefits of Cargotecture primarily include a decrease in cargo damage and more effective logistical operations, which lead to faster boarding and disembarkation, a rise in worked volumes, and a sharp decrease in handling costs. Additionally, further author stated that since it can be transported in its entirety as a container, can reduce the assembly and disassembly periods. According to Chang et al. (2011), many logistics-related variables may be eliminated by having practically all of the activities conducted under one manufacturing facility. Modular constructions are more ecologically friendly than traditional steel or concrete structures (Zafra et al., 2021). Authors further state that modular construction generates far less trash, giving it an advantage in having a lower environmental effect, which may result in time and cost savings over reduced waste charges. Amate and Brotas (2014) discovered that reusing shipping containers could save more than 80% of the embodied energy in an original steel modular system. It is critical to recognise the benefit given by modular modules, which may be readily dismantled and relocated as needed.

3. RESEARCH METHODOLOGY

A comprehensive literature review was conducted to gather information on problems in PDR projects and the benefits of cargotecture in PDR projects in the construction industry. The mixed method approach is used to achieve the aim of the study. Documentation, interviews, surveys, focus group discussions, observation, participatory arrangements, and qualitative audio-visual material are all methods for acquiring data in qualitative research (Dewi, 2021). Accordingly, the data was collected through two phases. Phase one included the questionnaire survey carried out to collect the data to identify the problems of PDR projects. Accordingly, forty-five construction industry professionals who have knowledge of the PDR project have participated through the snowball sampling method, generally, authors used a sample size of 30 for all validation scenarios (Aithal, & Aithal, 2020). The questions were provided as an online platform. This research adopted RII to analyse the quantitative data collected from the questionnaire survey, using Microsoft Excel. Phase two included the semi-structured expert interview conducted to identify the problems of PDR projects, investigate the benefits of cargotecture in PDR projects and to develop the framework to overcome the problems in PDR through the benefits of cargotecture in PDR projects in Sri Lanka. Ten semi-structured interviews with experts who have experience and knowledge on PDR projects, selected through a selective sampling method were conducted due to data saturation. Code-based content analysis was used to analyse the data collected from expert interviews using NVivo12.

4. RESEARCH FINDINGS

4.1 PROBLEMS IN PDR PROJECTS

The problems identified through the literature survey were sent to the respondents to identify the most critical problems. The validated data gathered by the questionnaire survey was analysed using the “RII approach.” Table 3 summarises the rankings of the problems in PDR projects.

Table 3: Ranking of the problems in PDR projects

No.	Problem	RII	Rank
1	Financial management	0.847	1
2	High time consumption	0.807	2
3	Political factors	0.787	3
4	Coordination and communication issues	0.780	4
5	Supply chain dysfunction	0.760	5
6	Resources shortage	0.740	6
7	Poor quality of work	0.740	6
8	Infrastructure breakdown	0.720	7
9	Corruption	0.720	7
10	Public policies	0.713	8
11	Health and safety issues	0.700	9
12	Beneficiary identification and participation	0.687	10
13	Information and knowledge dissemination	0.673	11
14	Lack of technical and managerial expertise	0.667	12

The results of the questionnaire survey have shown that RII values of the problems of the PDR projects fell between 0.847 and 0.667. Table 3 shows a collection of PDR problems ranked by the RII value based on their perceived severity. With an RII score of 0.847, "financial management" is regarded as the essential concern, followed by excessive time consumption with a value of 0.807. Further, "High time consumption" has been chosen as the second most critical problem in PDR projects and "Political factors" were identified as the third. "Coordination and communication issues" has been identified as the fourth significant problem in PDR projects by the respondents. Political considerations, coordination and communication challenges, and supply chain dysfunction are also prominent, illustrating the complex interplay of social, economic, and political variables in post-disaster reconstruction operations. Additional obstacles include a lack of resources, poor job quality, infrastructure collapse, corruption, and public policy. Health and safety difficulties, beneficiary identification and engagement, information and knowledge transmission, and a lack of technical and administrative competence are all key obstacles that must be addressed in the aftermath of a tragedy. Finally, Figure 1 illustrated the research outcome of problems in PDR projects.

Figure 1: Problems in PDR projects

Through the questionnaire survey, the main problems of the PDR projects were identified. Experts also raised a few problems in PDR projects. The most critical problems identified by experts are discussed in Table 4. Table 4 summarises the main problems in PDR projects. After Validating the identified problems of the PDR projects through the questionnaire survey, those validated problems were further confirmed by the experts during the interviews.

Table 4: Main Problems in PDR Projects

No	Problem	Literature	E 1	E 2	E 3	E 4	E 5	E 6	E 7	E 8	E 9	E 10
1	High time consumption	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
2	Financial Management (Allocation of funds for the project)	✓	✓	✓	✓	✓	✓	✓		✓		
3	Supply chain dysfunction	✓		✓	✓	✓	✓	✓			✓	✓
4	Resources shortage	✓			✓	✓	✓		✓	✓	✓	✓
5	Coordination and communication issues	✓	✓	✓	✓	✓	✓	✓	✓			✓
6	Infrastructure breakdown	✓		✓	✓	✓	✓		✓	✓	✓	✓
7	Corruption	✓	✓		✓	✓			✓	✓	✓	
8	Lack of technical and managerial expertise	✓	✓		✓	✓	✓	✓	✓	✓		✓
9	Lack of guidance		✓		✓	✓	✓			✓		✓
10	Poor quality of work	✓	✓	✓	✓	✓	✓	✓			✓	
11	Health and safety issues	✓	✓	✓	✓	✓	✓			✓	✓	✓
12	Political factors	✓	✓			✓			✓	✓		✓
13	Public policies	✓	✓			✓			✓	✓	✓	✓
14	Beneficiary identification and participation	✓			✓		✓	✓	✓	✓	✓	
15	Information and knowledge dissemination	✓	✓			✓	✓		✓	✓	✓	✓
16	Acquiring a secure land to resettle				✓		✓					
17	Identifying the needs of the victims					✓	✓					
18	Supplying a large number of materials		✓		✓		✓					

All ten experts agreed that high time consumption is a main problem in PDR projects. E2, E4, E6, E7, E9 and E10 stated that the main problem of PDR projects is high time consumption. But E1, E3, E5 and E8 stated that the main problem is allocating funds. E1 stated that *"Most times, the government has to allocate funds for projects. In most cases, the reason for slow construction is the financial issues"*. Acquiring secure land for resettlement was identified as a problem in the PDR project by E3 and E5. E3 stated that the victims need to be re-settled in a land that is located as close as possible to the previous accommodations. E3 further stated that "*There is a principle that the most affecting category of a disaster is low-income population. The reason for it is they are living in the most hazardous places. In most times, their livelihood is related to their living area."* According to E3, supplying a large number of building materials at once for a large-scale reconstruction project is a challenge. E3 further stated that the material prices could be increased due to the sudden demand. According to E4, identifying the needs of the victims of the reconstruction project is also a problem. E5 stated that coordination and communication issues between the authorities are critical. However, E3 stated that *"After* *appointing the Disaster Management Centre (DMC), we were able to resolve those communication issues".*

4.2 BENEFITS OF INTEGRATING CARGOTECTURE FOR PDR PROJECTS

The benefits of integrating cargotecture for PDR projects were identified through a literature survey and expert interviews. Table 5 summarises the benefits of integrating cargotecture for PDR projects.

Table 5: Benefits of Integrating Cargotecture for PDR Projects

No	Benefit	Literature	E 1	E 2	E 3	E 4	E 5	E 6	E 7	E 8	E 9	E 10
1	Reduce the construction duration	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	Resource availability and integration	✓										
3	Ability to endure corrosion	✓	✓	✓						✓		
4	High Durability	✓	✓				✓					✓
5	Economical (Less initial cost)	✓	✓			✓		✓	✓	✓		✓
6	Seismic stability	✓						✓			✓	
7	Availability and skills of the workforce	✓										
8	Minimise the involvement of expertise in planning	✓										
9	Overall quality and end-user satisfaction	✓										
10	Promote Sustainability	✓	✓				✓	✓				✓
11	Reduced site labour requirement	✓	✓	✓	✓		✓			✓		
12	Environmentally less sensitive	✓										
13	Modularity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
14	Transportability	✓	✓	✓	✓		✓	✓	✓	✓		✓
15	Demountability after usage	✓			✓				✓		✓	✓
16	Low weight	✓										
17	Reduce the land consumption		✓					✓		✓		

All the experts agreed that integrating Cargotecture for PDR projects will reduce the construction duration and modularity. Expert 6 stated that "*Obviously, it will take less time compared to conventional buildings, and the cost will also be reduced. Before that, needs to be investigated the geotechnical conditions and have to make proper arrangements."* Further, most of the experts agreed that integrating Cargotecture for PDR projects helps to reduce initial cost and site labour requirements and provide transportability. However, all the experts argued that resource availability and integration, availability and skills of the workforce, minimise the involvement of expertise in planning, overall quality and end-user satisfaction, environmentally less sensitivity and low weight are not applicable benefits of Integrating Cargotecture for PDR Projects in the Sri Lankan construction industry.

5. DISCUSSION

The research aims to develop the framework to overcome the problems in PDR through the benefits of cargotecture in PDR projects in Sri Lanka. As a result, experts were assigned with matching the path to solving problems in PDR through the benefits of cargotecture in PDR projects in Sri Lanka. Figure 2 depicts the proposed framework for overcoming the problems in PDR projects through the benefits of cargotecture in PDR projects in Sri Lanka.

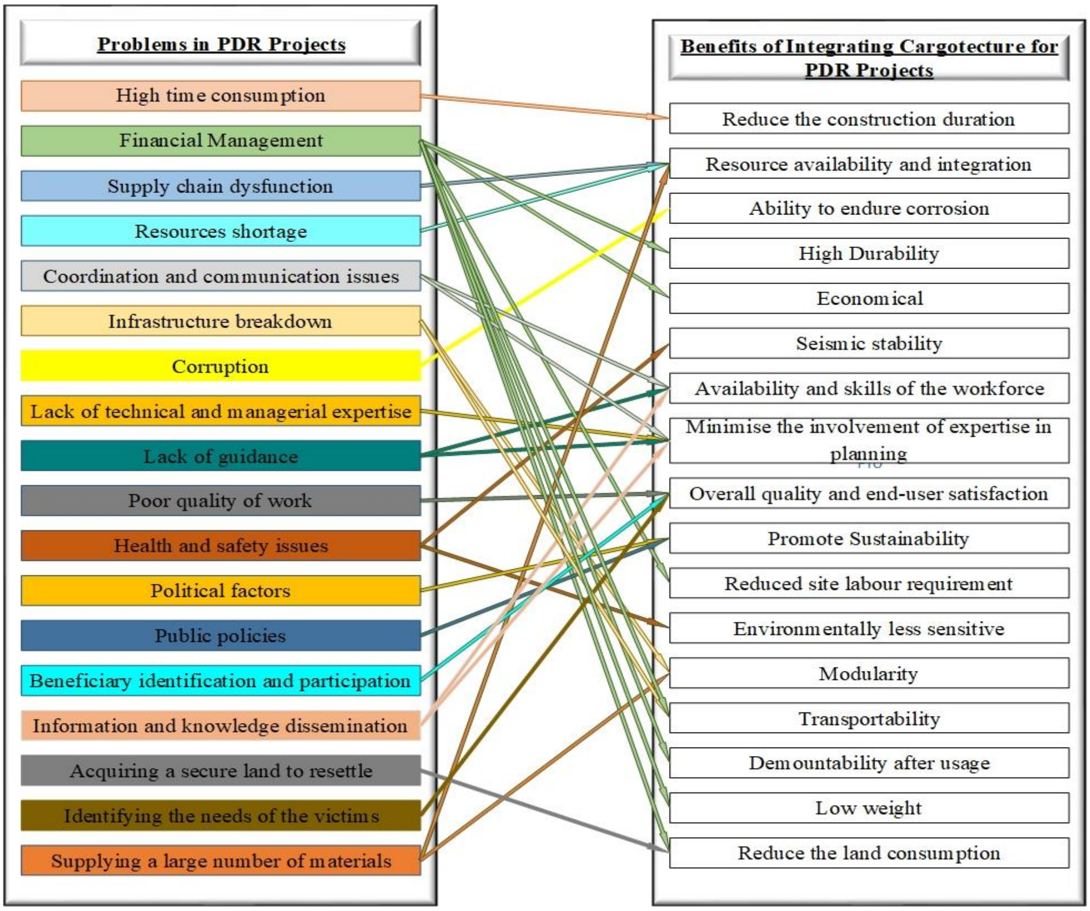

Figure 2: Framework for overcoming the problems in PDR projects through the benefits of cargotecture

As a result, the study found that the majority of the problems in PDR projects in Sri Lanka had been overcome through the use of cargotecture. The literature review of the study identified several problems of the PDR projects. However, during the data analysis, several other problems of PDR projects were identified by the experts. Hidayat and Egbu, (2010) stated that reconstruction is often a long-term recovery operation that is slow, expensive, and difficult. According to the RII analysis of the problems in PDR projects identified through the literature review, the most significant problem was financial management. Tas et al. (2010) identified time to have a significantly higher rank over the other factors, including cost reduction of the project, which affects determine the design of post-disaster permanent housing reconstruction. However, according to the responses, the current study introduces that in Sri Lankan PDR projects, financial management is the most significant problem in comparison to the speed of construction. According to literature findings, coordination and communication issues were one of the main problems in PDR projects. The current study also identifies coordination and communication issues as the main problem. Furthermore, Siriwardhana et al. (2021) and Rotimi et al. (2006) stated that it is challenging to create effective communication between resettlement agencies and affected populations. However, experts of the study stated that this coordination gap often leads to duplications, misallocation of resources, and delays in project implementation. The study identified that to address this challenge, the Sri Lankan government has established the National Disaster Management Centre (NDMC) to coordinate PDR efforts. Le Masurier et al. (2006) stated that if disasters were on a relatively small scale, there was not much difference between the typical building process and the reconstruction procedure unlikely to be a large-scale disaster. Bilau et al. (2017) indicated challenges associated with logistics and supplies as one of the major management issues that arise in large-scale housing reconstruction programmes. In addition, Rotimi et al. (2006) highlighted that it is difficult to obtain regular resource levels after a catastrophic event, and it might be difficult for poorer countries to access resources for PDR. Jayasuriya and McCawley (2008) stated that when natural resources are rare locally, reconstruction efforts following disasters in a nation like Sri Lanka have to depend on assistance from outside. This research also identifies that resource shortage is a critical problem in PDR projects. Industry experts stated that there are several problems in PDR projects, in Sri Lankan projects such as acquiring secure land to resettle, identifying the needs of the victims, and supplying a large number of materials.

Sun et al. (2017), the use of cargotecture has grown significantly in recent years due to its robust plating, low cost, and ubiquitous availability. According to Chen et al. (2016), Gunawardena et al. (2014), and Lawson et al. (2012), the prefabricated modular technology has the potential to significantly reduce the amount of construction time that can be adopted for PDR projects. The findings of this study also agreed that adopting cargotecture for PDR will reduce the construction duration. According to Lawson et al. (2012), labour-intensive builds onsite. According to Pena et al. (2012), cargotecture has been provided temporary home design options that capitalise on shipping containers' natural strengths, reusability, and portability. The current study validated the other benefits of cargotecture, such as demountability after usage, modularity, and transportability, unlike traditional construction. This study further identified that cargotecture would reduce land consumption, which is also a critical problem in PDR. Tas et al. (2010) identified the availability and skills of the workforce and minimise the involvement of expertise in planning as benefits of cargotecture. El Messeidy (2018) stated that cargotecture is an environmentally sustainable solution, as it promotes the use of recycled materials and reduces the carbon footprint of construction. The current study also agrees that cargotecture is a sustainable and eco-friendly building solution that can minimize the environmental impact of construction activities. By repurposing shipping containers, builders can reduce the demand for new building materials and minimize waste.

6. CONCLUSIONS

The aim of the research was fulfilled by conducting a review of the existing literature and collecting data through a questionnaire survey and expert interviews. In Sri Lanka, PDR projects are critical for restoring communities following natural disasters such as floods, landslides, and cyclones. Unfortunately, difficulties have arisen throughout the execution of PDR projects in Sri Lanka. In Sri Lanka, PDR projects suffer from a lack of financing and resources, resulting in delayed execution, limited rehabilitation efforts, and low-quality infrastructure. The lack of competent knowledge of labour and disaster management also hinders the proper implementation of PDR projects. Further, the study identified that cargotecture could offer several benefits in PDR projects in Sri Lanka. Reducing the construction duration, less initial cost, low weight, promotion sustainability, reduced site labour requirement, demount ability after usage, modularity, transportability, and reduced land consumption were identified as the benefits of cargotecture in PDR projects in Sri Lanka in this study. Overall, cargotecture can provide an efficient, cost-effective, and sustainable building solution for PDR projects in Sri Lanka. Finally, the study provided a framework for overcoming problems in PDR projects through the benefit of cargotecture in PDR projects in Sri Lanka. Consequently, the study revealed that most of the problems in PDR projects have been overcome through the benefit of cargotecture in PDR projects in Sri Lanka. The modular nature of shipping containers and their resilience to natural disasters can also provide flexibility and ensure that the built environment remains functional in the face of future disasters.

The study recommended integrating Cargotecture for PDR projects in Sri Lanka to overcome the problem in PDR projects. In addition, the research contributes to knowledge about problems in PDR projects in Sri Lanka and the benefits of integrating Cargotecture for PDR projects in Sri Lanka. Furthermore, this study opens the research area on developing a framework for integrating cargotecture for PDR projects in Sri Lanka to increase cargotecture adoption in PDR projects in Sri Lanka. Thus, the study findings cannot be generalised in the global context since this study only focused on Sri Lanka. Therefore, any other developing nation that is similar in nature to Sri Lanka's construction industries and that shares the same socioeconomic, cultural, and demographic characteristics can conduct further studies to build a framework for integrating cargotecture for PDR projects in their nation to boost cargotecture adoption in PDR projects. However, there were several problems in successfully integrating cargotecture for PDR projects in Sri Lanka when it was implemented to address the problems with PDR projects. As a result, it is recommended that future research focus on the problems associated with integrating cargotecture for PDR projects in Sri Lanka as well as strategies for overcoming these problems. This will help to develop a framework for integrating cargotecture for PDR projects in Sri Lanka and promote cargotecture adoption in PDR projects in Sri Lanka.

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