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Institute of Quantity Surveyors Sri Lanka (IQSSL), as the sole body representing the quantity surveying profession in Sri Lanka, holds its Annual Technical Sessions with the intention of sharing and updating knowledge in the field of quantity surveying and fields related to the Built Environment, including Architecture, Engineering, and Facilities Management. Parallel to the Annual Technical Sessions, IQSSL publishes this Technical Research Proceeding with the intention of providing a forum for researchers, academics, practitioners, and students to share their knowledge, interests, and experience in the field of quantity surveying.

This year, IQSSL has organized the annual forum on the theme of “Quantity Surveyors’ Role in the Economic Revival of Sri Lanka: Leveraging Business Acumen and Commercial Management for Development”. Parallel to this event, prospective authors are invited to submit their papers related to annual forum main theme and other various sub themes as indicated in the call for papers.

All received full papers were sent to a panel of scientific reviewers and at least two reviewers contributed double-blind peer review, providing constructive comments regarding originality, significance, reliability, quality of presentation and relevance to the scope of each paper. Selected papers by the scientific review panel are published in this technical proceeding 2023.

At this moment, I acknowledge and highly appreciate the all the authors who submitted their valuable research papers for this publication. It is my duty to extend my gratitude to the members of the scientific review panel for their untiring commitment and dedication voluntarily in providing comprehensive reviews. I extended my special thanks to Ch.QS. Dhamisha Sriyananda, Miss. Dinithi Piyumra and Miss. Janani Kumarathunga for the coordinating & editorial support they provided in this process

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PAPERS

A STUDY OF MICRO HYDROPOWER IMPLEMENTATION IN SRI LANKA

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A STUDY OF MICRO HYDROPOWER IMPLEMENTATION IN SRI LANKA

ABSTRACT

The micro hydropower sector is developing into a regenerative energy solution for the present energy crisis and has enormous social benefits. Despite being a third world developing nation, Sri Lanka still has rural areas that are very remote from the city and the primary electricity source. In that situation, the implementation of non-renewable energy generation and upkeep processes are more expensive. The most remote regions are found in the upcountry and are abundant in water sources due to the terrain of the nation. Therefore, the aim of this paper is to examine the suitability of Micro Hydropower Projects (MHP) in Sri Lanka. The study used a qualitative approach, which involved collecting data through semi-structured interviews. The research results provide insights into the factors that affect the adoption of micro hydropower in Sri Lanka. These factors can be categorized into five main viewpoints: economic, technical, social, environmental, and legal. A total of twenty benefits of implementing micro hydropower in Sri Lanka were discovered. The implementation of micro hydropower in Sri Lanka offers a trifecta of compelling benefits. By harnessing the innate flow of water, this renewable energy source epitomizes sustainability, as it taps into a perpetually replenished resource.

Keywords: *Benefits; Implementation; Micro Hydropower (MHP); Sri Lanka*

1. INTRODUCTION

Electricity is the best scientific discovery ever (Zheng et al., 2019). Power is being used for everything in our civilization, according to Rajkumari (2020). Without it, our existence would not be possible. Electricity is a type of energy source. It is produced by a battery, a coil of wires, or a dynamo machine. It is produced using both renewable and non-renewable energy sources. Globally, 0.9 billion people lack access to electricity as of 2016, and this number will drop by 0.4 billion over the next four years (Soytas and Sari, 2006). Rural communities typically suffer the most from a shortage of energy (Amin, 2015). Additionally, another 2.5 billion people still rely on other conventional energy sources, which contribute to environmental problems like air, sound, water, and soil pollution (Omer, 2008). As a third world developing nation, Sri Lanka is likewise dealing with the energy issue. According to the most recent census conducted by the Sri Lankan government for the years 2010 to 2015, it is suggested that in order to meet the nation's energy needs, electricity generation should be increased by 4,200 MW over the course of the next 15 years (Ceylon Electricity Board Annual Report, 2016).

However, the Ceylon Electricity Board Annual Report (2016) states that the per capital electricity usage was 626 kWh at the beginning of the year and 650 kWh at the end of the year, with an increase of 24 units noted in 2016. Given the rising demand for electricity, both rural and urban areas need to build alternate electricity generating sources with resilience in an adaptable and flexible manner (Gebreslassie *et al.*, 2022). Since the development of the first hydroelectric power plant in Sri Lanka in the late 1950s, hydroelectricity generation has played a significant role in the country's power generation industry (Wijesinghe and Lei, 2011). Micro hydro power (MHP) projects provide a variety of advantages over mega and tiny hydropower projects when the considerations of resource scarcity, the complexity of major hydropower projects, high maintenance costs, and significant risk are taken into account. MHPs are more practical for rural areas due to these factors. The challenges posed by resource scarcity, the intricate nature of major hydropower projects, high ongoing maintenance costs, and the substantial risk associated with larger projects collectively make micro hydropower a more viable and practical energy solution for rural environments (Zema *et al.*, 2016). However, there are limited studies can be found on MHPs implementations (Deshamukhya and Choubey, 2022; Omer, 2008). In the context of the present situation in Sri Lanka, a prominent challenge in ensuring reliable electricity access to rural areas

revolves around the considerable expenses associated with both establishing and maintaining power infrastructure (Dhanasekara, 2023). The cost-intensive nature of these processes significantly hampers efforts to extend essential electricity services to remote communities, where economic limitations often intersect with geographical barriers (Deshamukhya and Choubey 2023). MHP projects are highly suitable for Sri Lanka due to the country's abundant water resources, diverse topography, and significant energy demand, particularly in rural areas. With a reliance on renewable energy sources becoming increasingly imperative, MHPs offer a localized and sustainable solution that can provide reliable electricity access, promote economic development, and reduce carbon emissions (Bhandari *et al.*, 2018), aligning with Sri Lanka's goals for energy security and environmental preservation. Considering the studies from the overseas regions, this research aims to examine how the suitability of implementation of MHP in Sri Lanka. Further, the objectives of the study were to (1) identify the factors affecting micro hydropower implementation in Sri Lanka and (2) benefits of micro hydropower implementation in Sri Lanka.

2 LITERATURE REVIEW

2.1 MICRO HYDROPOWER AS A MODERN SOLUTION TO ENERGY DEMAND

Micro-hydropower (MHP) generation is one of the most significant renewable energy solutions for rural electrification in developing nations (Paish, 2002), especially in mountainous regions with sufficient water supply (Arnaiz *et al.*, 2018). This is due to the fact that MHP generation is both affordable and ecologically benign; it offers the best economic option and is crucial for a sustainable future (Date and Akbarzadeh, 2009). The best option for priority development in Sri Lanka may be MHP, given its potential and advantageous location.

Although micro-hydropower is an environmentally friendly source of energy, larger hydropower sources have the potential to have detrimental social and environmental effects. A hydroelectric project has negative effects on society and the environment (Aung *et al.*, 2021), including reduced sediment transport and significant changes to river hydrology (Zheng *et al.*, 2019). According to Wang *et al.* (2021), 236 small hydropower facilities had some negative effects on river connectivity, which resulted in a variety of environmental issues. Some of these issues include disrupted aquatic ecosystems, altered sediment transport patterns, diminished fish migration routes, reduced water quality due to stagnation, and potential impacts on local flora and fauna. The categorization of hydropower is dependent on the circumstances of each nation. MHP is categorized in several nations as a power plant with a capacity under 100 kW, including the USA, India, and Brazil (Bracken *et al.*, 2014). Because MHP is a run-of-river power plant and the river is not changed into a lake or the flow pattern is not altered, it does not require a reservoir that can prevent the appearance of social and environmental consequences. This power plant is chosen to be built since it has little social and environmental effects, especially in distant places.

2.2 IMPORTANCE OF MICRO HYDROPOWER IMPLEMENTATION PROJECTS IN SRI LANKA

Small-scale hydropower has become a viable and affordable alternative source to provide medium-term electricity generation for the rural population, according to Kashyap *et al.* (2020), using small hydro as a supplier to the national grid is the most recent development of small hydro. These are private sector commercial endeavours. Sri Lanka is a tropical weather country that has better geomatic features and weather patterns to develop MHPs and those locations are situated near human habitats (Patro *et al.*, 2020).

To offset the nation's existing electricity demand, it is crucial to choose an alternate energy source. Out of several potential energy sources, "hydro" is the best option as a renewable energy source to provide power with minimal harm to people and the environment (Bhandari *et al.*, 2018). Nag and Sarkar (2021) published that MHP's contribution to the National electricity demand will be the cheapest source

compared to other renewable energy sources. As a South Asian country, Sri Lanka has similar geographic features to India. In that case, Hussain *et al.* (2019) clearly show that India has many opportunities to implement new MHP projects. Considering the geographic similarity Sri Lanka also has the same viability to implement new MHP projects gradually. In India, most of the rural villages are away from the main towns in the districts, and it causes the development of their infrastructure facilities due to the high initial cost and the high maintenance cost. With the above-mentioned factors, Sri Lanka has a good potential chance to implement MHP in every area which can develop the MHP plants.

3 RESEARCH METHOD

Qualitative expert interviews and manual content analysis are suitable methods for data collection and analysis, respectively, in a study of micro hydropower implementation in Sri Lanka due to several reasons. A qualitative approach is well-suited for a study of micro hydropower implementation in Sri Lanka because it allows for in-depth exploration and understanding of the complex socio-technical factors involved. Additionally, qualitative research can shed light on how these projects impact employment opportunities, and environmental sustainability, ensuring a comprehensive understanding that goes beyond numerical data (Dawson *et al.*, 2007). Also, semi structured expert interviews allow researchers to gather in-depth and rich insights from individuals who possess expert knowledge and experience in the field (Creswell, 2013). Sri Lanka's micro hydropower sector may involve various stakeholders, such as government officials, industry experts, and community leaders. Conducting expert interviews enable researchers to explore diverse perspectives and gain valuable insights into the social, economic, and environmental aspects of MHPs in Sri Lanka and manual content analysis is employed as a data analysis method.

According to Etikan (2016), purposive sampling, also known as judgment sampling, is a technique used to select participants intentionally based on specific traits or characteristics. It involves purposefully determining the sample based on the researcher's judgment and the research aim. In the context of the construction industry, purposive sampling allows researchers to select interviewees who possess knowledge and interest in the specific area of study, as highlighted by Etikan (2016). This intentional selection ensures that the sample includes individuals who can provide valuable insights and expertise related to the research topic. Furthermore, Jansen (2010) emphasizes that a qualitative survey aims to capture the relevant diversity within the population of interest. In the case of the construction industry, this diversity could include professionals from different sectors within the industry, such as architects, engineers, contractors, and project managers. By employing purposive sampling, researchers can ensure the representation of this diverse range of experts in the study. Table 1 presents the profile of the interview respondents along with the criteria used to define experts for the research area which is the construction industry.

Table 1: Profile of Expert Selection

Coding for Panel Experts	Designation	Client	Contractor	Consultant	Years of Experience	Criteria						
						Compulsory Qualification		Additional qualifications (Satisfy at least three of the following criteria)				Accessibility
						C1	C2	A1	A2	A3	A4	
I.01	Director	✓			31 years	✓	✓	✓	✓		✓	✓
I.02	Director		✓		35 years	✓	✓	✓		✓	✓	✓

I.03	Senior Project Manager	✓	34 years	✓	✓	✓	✓	✓	✓
I.04	Senior Lecturer	✓	12 years	✓	✓	✓		✓	✓
I.05	Director		✓ 29 years	✓	✓	✓		✓	✓
I.06	Senior Engineer	✓	14 years	✓	✓	✓	✓		✓
I.07	Director		✓ 38 years	✓	✓	✓	✓	✓	✓
I.08	Senior Engineer	✓	28 years	✓	✓	✓	✓		✓
I.09	Director	✓	32 years	✓	✓	✓		✓	✓
I.10	Senior Lecturer	✓	10 years	✓	✓	✓	✓		✓
I.11	Senior Lecturer		✓ 14 years	✓	✓	✓	✓	✓	✓
I.12	Project manager	✓	24 years	✓	✓	✓	✓	✓	✓
I.13	Plant operator		✓ 23 years	✓	✓	✓	✓		✓
I.14	Director	✓	26 years	✓	✓	✓	✓	✓	✓
I.15	Quality Controller		✓ 31 years	✓	✓	✓	✓		✓

C1: Knowledge and better understanding in hydropower sector

C2: More than 10 years of experience related to the hydropower sector

A1: Graduate in an energy-related discipline

A2: A postgraduate degree related to hydropower/ environmental discipline

A3: Corporate member of a professional institution

A4: Practical experience/ research experience in sustainable or hydropower sector

In order to establish a solid foundation of knowledge and experience, as well as specialized expertise in the field of hydropower, certain criteria were implemented to select experts for interviews. Fifteen experts were chosen and interviewed, with each interview lasting between 45 to 60 minutes. To ensure consistency and thoroughness, a prepared interview guideline was used during the interviews.

4 RESEARCH FINDINGS

4.1 INFLUENTIAL FACTORS FOR MICRO HYDROPOWER IMPLEMENTATION IN SRI LANKA

The implementation of MHPs in Sri Lanka is influenced by various factors that encompass technical, environmental, regulatory, financial, social, and policy aspects. Technical feasibility is crucial, as it requires assessing water resources, topography, and grid connectivity to determine the viability of hydropower development. Based on insights derived from expert interviews, the research findings presented in Table 2 categorize the influencing factors into five primary perspectives: economic, technical, social, environmental, and legal.

Table 2: Influential Factors for Micro Hydropower Implementation

Perspectives	Factors
Economic Perspective	Electricity demand
	Current electricity supply
	Market demand for investment in micro hydropower
	Client’s budget
	Project cost
	Investment return
	Payback period
Technical Perspective	Availability of technology in the country
	Head of the water level
	Design of the structure
	Supply channel
	Forebay
	Penstock
	Skilled employees in the country
Social Perspective	Impact on culture heritage in the area
	Social disturbance

	Impact on the public structures, public facilities & community
	Social security of the society
	Benefits to the society
	Strategies to promote micro hydropower to the society
Environmental Perspective	Rainfall to the catchment area
	Reinstatement for existing built environment
	Affect to the animal habitats
	Impact on fish bridges
	Threat to the endemic plants
	Impact on the water cultivation
	Damages to the flora & fauna
	Accessibility to the location
	Threats from animals
	Safety level of the location
	Topography of the site
	Threats from humans (Security)
	Legal Perspective
Taxation on the hydropower projects	
Law provisions related to MHPs	

According to the experts in the industry, all the five perspectives are important and critical. However, economic perspective is more important since it reveals the necessity and the ability of implementing the micro hydropower plants. Further I.02 stated, *“Under the economic perspective, it has been identified seven factors such as, electricity demand, current electricity supply, market demand for invest in micro hydropower, client budget, project cost, investment return, and payback period”*. When considering these factors, the most highlighted factors were electricity demand and the current electricity supply. This is because, electricity demand will determine the necessity of the micro hydropower plant and current electricity supply will determine the percentages of the people in a particular area who are getting the electricity and capacity of the micro hydropower plant.

Moreover, I.05, I.09 and 1.10 highlighted the technical perspective should also be considered before implementing a micro hydropower plant. Under this perspective, it has been identified several factors such as, availability of the technology in the country, head of the water level, supply channel, penstock and the skilled employees in the country. Among the factors influencing micro hydropower plant implementation, the availability of the technology in the country emerged as the paramount concern, a consensus agreed upon by all experts. This factor holds pivotal importance as it directly determines the success of the implementation process. Further, all the expertise in the industry believe that Sri Lanka has the technology required to implement a micro hydropower plant. Then the next perspective is, social perspective. Under this aspect, it has been recognized several factors affect the implementing of micro hydropower plants. Those factors are social disturbance, impact on the public structures, public facilities and communities, and benefits to society. Among these factors, social disturbance and impact on public structures were highlighted as the most critical factors in implementation. Society plays a huge role when implementing a new project in a particular region. Therefore, all the expertise interviewed, identified those factors as critical factors. Next, environmental perspective is considered during the interviews conducted with the expertise. More factors have been identified under this perspective such as, rainfall to the catchment area, effect to the animal habitats, threat to the endemic plants, safety level of the location and other factors. When considering these factors, the most highlighted factors under this perspective were, rainfall level to the catchment area and safety level of the location. In addition, all the expertise had identified other factors as common factors. According to the interviewees, rainfall is important for hydropower plants since it operates from energy stored in the flowing water and further, there must be continuous water flow even in the dry season in order to operate the plant continuously. Furthermore, I.15 stated, *“When considering the safety aspect, the location of the plant should not be*

interrupted by various factors such as thieves, animals, and natural disasters such as floods". Then the final perspective is the legal perspective. Under this aspect, taxation imposed by the government has been identified as the main factor. When the taxation related to hydropower plants is increasing, the budget of the client or the amount of the investment to the project will rise and this will lead to a decrease in the implementation of micro hydropower plants in the country.

4.2 BENEFITS OF MICRO HYDROPOWER IMPLEMENTATION IN SRI LANKA

The implementation of micro hydropower in Sri Lanka offers several benefits. It provides a sustainable and renewable source of energy, reducing the country's reliance on fossil fuels and mitigating greenhouse gas emissions. It can be gained more benefits by implementing micro hydropower plants. According to Table 3, all the benefits were identified during the interviews.

Table 3: Benefits of Micro Hydropower Implementation in Sri Lanka

No	Benefits
1	Micro hydropower utilizes the natural flow of water, making it a renewable and sustainable energy option
2	Generating electricity from water reduces the need for fossil fuels, leading to lower carbon dioxide emissions
3	Micro hydropower allows Sri Lanka to reduce its dependence on imported energy sources and enhance its energy security
4	Once the infrastructure is set up, the operational costs of micro hydropower are relatively low, resulting in cost savings for the country
5	Implementation of MHPs creates employment opportunities in construction, operation, and maintenance of the facilities
6	MHPs often involve local communities, promoting social and economic development in rural areas
7	Remote and off-grid communities gain access to electricity through micro hydropower, improving their quality of life and enabling economic activities
8	Micro hydropower provides a consistent and reliable source of electricity, reducing power outages and enhancing the stability of the grid
9	Integrating micro hydropower into Sri Lanka's energy mix diversifies the country's energy sources, reducing reliance on a single type of generation
10	MHPs have minimal negative environmental impact compared to large-scale hydropower dams, preserving ecosystems and aquatic life
11	Locating micro hydropower plants close to the demand centers minimizes transmission losses, increasing the overall efficiency of the energy system
12	MHPs promote responsible water management by utilizing water resources efficiently and minimizing water wastage
13	Micro hydropower systems are less vulnerable to natural disasters compared to centralized power plants, ensuring continuous electricity supply during emergencies
14	Micro hydropower can replace diesel generators in remote areas, leading to lower fuel consumption and reduced air pollution
15	MHPs can provide irrigation for agricultural purposes, enhancing crop yields and supporting agricultural development
16	Micro hydropower allows communities to maintain their traditional ways of life by providing electricity without altering their cultural heritage
17	Access to electricity through micro hydropower facilitates the establishment of schools and educational institutions in remote areas
18	Reliable electricity supply enables better healthcare services, including refrigeration for vaccines, lighting for medical facilities, and powering medical equipment
19	Micro hydropower supports the growth of small businesses and entrepreneurship in rural areas, driving economic growth and poverty reduction
20	Surplus electricity generated by micro hydropower systems can be sold to the grid, providing additional income for communities or project owners

According to the expert in the industry, implementing a micro hydropower plant will be more beneficial to the economy of the country. According to expert, the current world is facing an energy crisis, and this will be increased in future. Since availability of the fossil fuel is diminishing day by day, usage of renewable energy has increased. Therefore, using hydrology for generating electricity is becoming popular in most of the countries in the world. Further, I.06 stated, *“Implementing a micro hydropower plant will be economically beneficial since the source for generating energy is long lasting”*. Therefore, the durability and the existence of the plant will be high. In addition, since the source is supplied naturally, electricity can be generated throughout the day. This is one of the benefits highlighted during the interviews by the interviewees.

Moreover, several benefits under environmental aspect can be identified as well. Those benefits are, zero emissions of harmful gases, has high utilization factor compared to other renewable energies, and tool for reclamation and as an irrigation system. Among these benefits, the most highlighted benefit was the zero emissions of harmful gases. Since micro hydropower plants use natural source, and the natural energy stored in the water to generate electricity, it is not necessary to give energy artificially. Therefore, there is not harmful substances or gases emissions in these types of plants. Further, there are many social benefits by implementing micro hydropower plants. Also, I.12 stated, *“Improving the productivity of the works and increasing the working hours of beneficial are the main benefits highlighted during the interviews”*. Implementing hydropower plants facilitates to distribute electricity and this will help to increase the working hours and ultimately this will increase the productivity of the country as well. Further, another factor that was highlighted during the interviews was implementation of these type of projects will increase the available hours for studying for students and it will increase the literacy in particular region. Next, social benefit is reducing unemployment of the country. Since it facilitates several tasks to people such as operating, maintaining, securing and other tasks, people can obtain job opportunities. Finally, these benefits will increase the quality of the life of the people. In addition, implementing micro hydropower plants will benefit technically and industrially as well.

5 CONCLUSIONS

The research findings shed light on the factors influencing the implementation of micro hydropower in Sri Lanka, which can be classified into five key perspectives: economic, technical, social, environmental, and legal. Understanding these factors is crucial for successful project implementation. Additionally, the benefits of micro hydropower in Sri Lanka are significant and wide-ranging. It offers a cost-effective and sustainable energy source, reduces greenhouse gas emissions, enhances energy independence, and creates employment opportunities. Moreover, micro hydropower improves access to electricity, stimulates community development, supports education and healthcare services, and preserves the environment. Furthermore, it contributes to the diversification of energy sources, promotes responsible water resource management, and attracts international cooperation and funding. Considering these findings, micro hydropower implementation emerges as a promising solution for Sri Lanka, providing multiple advantages across various sectors while paving the way for a more sustainable and resilient energy future. Further investigations could delve into the integration of innovative technologies for efficient energy storage and distribution, enhancing the overall reliability of micro hydropower systems. Additionally, exploring the potential for policy adjustments and regulatory frameworks that incentivize private sector participation, community engagement, and sustainable environmental practices within the micro hydropower sector could contribute to a more holistic understanding of its long-term feasibility and socio-economic benefits.

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APPLICABILITY OF AGILE PRINCIPLES FOR POST-DISASTER RECONSTRUCTION (PDR) PROJECTS IN SRI LANKA

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APPLICABILITY OF AGILE PRINCIPLES FOR POST-DISASTER RECONSTRUCTION (PDR) PROJECTS IN SRI LANKA

ABSTRACT

Post Disaster Reconstruction (PDR) is vital in rebuilding a country after a disaster. The applicability of Agile principles is tested through this study for the PDR projects in Sri Lanka. Under the qualitative approach expert interviews were conducted with the managerial level staff who have experience in PDR projects in Sri Lanka. Data were analyzed through content analysis. Agile themes such as “Team-oriented methods, Assign the most suitable person as risk handling party, Rapid responsiveness, End-user feedbacks, Time management, Modern communication, and Section-wise procuring” which were derived from the literature were tested for applicability of Agile principles in the Sri Lankan context. Further, the findings revealed political involvement, practical issues, initial cost, stress, computer resources and depend on the team or one person are reasons for the non-compliance of agile principles to PDR projects. The dynamic and complex process, planning, quality problems, funding, and environment and construction conditions are ways to overcome PDR challenges through agile principles.

Keywords: Agile; Agile Construction; Challenges; Post Disaster Reconstruction; Sri Lanka.

1. INTRODUCTION

Post-disaster reconstruction needs expert involvement (Silva, 2010). On the other hand, post-disaster reconstructions are one of the new opportunities for investment and growth, resource utilization in a sustainable way, human capital constitution, new occupations, and human development (Shanmugaratnam, 2005; Thurairajah, Amaratunga, & Haigh, 2008). A well-planned reconstruction is critical to a developing country after a disaster. According to Gajendran, MacKee, and Brewer (2011) being ‘Agile’ can help to deal with labour, plant, material, information, and financial flows in a reconstruction project in an effective manner. Considering procurement, according to Nicoletti (2017), Agile procurement is a set of tools and is aimed at the effectiveness, efficiency, and economy of the construction project. Further, lean and digitalization are interrelated concepts in agility (Karre, Hammer, & Ramsauer, 2018). Effective PDR project requires a flexible construction process which enables addressing the challenges of post-disaster reconstruction such as fast construction, reduce wastage, and established quality (Myburgh, Wilinon, & Seville, 2008). Agility is an overall strategy focused on thriving in an unpredictable environment (Sanchez & Nagi, 2001), while the unpredictable environment is a key characteristic of PDR projects. Thus, the applicability of Agile principles to PDR projects is required to be investigated. Siriwardhana *et al.* (2021) demonstrated that the PDR projects in Sri Lanka are facing several challenges. Therefore, this study investigates the applicability of Agile principles to the PDR process.

2. LITERATURE REVIEW

DISASTERS AND DISASTER MANAGEMENT

There is no universally accepted concrete definition of disaster. However, according to ADRC (2020), a disaster is defined as “A severe interruption of the day-to-day operations of society, causing critical human, material or environmental losses which exceed the ability of society to bear the loss using only its resources. According to The World Bank, (2020) Since 1980, natural disasters caused over two million deaths and over \$3 trillion in economic loss, the critical fact is the per annum damage the disaster in the world is increasing by 600% compared to 1980, reporting from \$23 billion a year in the 80s to \$150 billion a year in the recent decade. Many researchers have identified, analyzed, and categorized the effects of disasters. Carroll, et al (2010) cited that there are a lot of critical social effects of disasters such as psychosocial, sociopolitical, socioeconomic, and sociodemographic impacts. Due

to the critical effect of a disaster, every nation follows its disaster management plan (Coppola, 2006). Carter (2008) has developed a comprehensive disaster management cycle as illustrated in Figure 1.

The disaster management plan will guide the reconstruction builders of damaged infrastructures and buildings (Palliyaguru, Amaratunga, & Haigh, 2010). According to Hidayat & Egbu (2010), the reconstruction phase plays an essential role in the disaster management cycle. Thus, a disaster management plan is also vital to the reconstruction process.



Figure 1: Phases of Disaster Reconstruction

POST DISASTER RECONSTRUCTION

According to WHO (1990) and Shaw (2006) relief, rehabilitation, recovery, and reconstruction are the key activities in rebuilding a country or region affected by a disaster. Thus, reconstruction as the final stage takes a vital part in rebuilding a country after a disaster. As cited by Ratnayake & Rameezdeen, (2008); Barenstein (2006) there are five approaches to post-disaster constructions according to the funding methods, namely, the owner-driven approach, the participatory housing approach, the subsidiary housing approach; the contractor-driven approach ex nihilo, and the contractor-driven approach in situ. However, Chang, Wilkinson, Potangaroa, and Seville (2011) classified the modern reconstructions according to resource strategies adopted in the reconstruction as government-driven, market-driven, donor-driven, and owner-driven for all kinds of reconstructions.

CHARACTERISTICS OF PDR PROJECTS

Characteristics of the post-disaster reconstruction projects are significantly changed in contrast with the common construction. Mesurier, Rotimi, and Wilkinson (2006) mentioned that most of the countries follow a framework for recovery and reconstruction after disasters, and reconstructions generally followed the framework. Table 1 shows the literature findings of key characteristics of a PDR project.

Table 2: Characteristics of a PDR project

Characteristic	Sources
Rules and Regulations	(Mesurier, Rotimi, & Wilkinson, 2006)
Nature of the PDR project	(Silva, 2010).
The complexity of the PDR project	(Boano & García, 2011), (Chang, Wilkinson, Potangaroa, & Seville, 2011).
Professionals' involvement in PDR projects	(Thayaparan, et al., 2015), (Chang, Wilkinson, Potangaroa, & Seville, 2011),

Investment, sustainability, Time availability, Approaches for the PDR project	(Alexander, 2004), (Barakat, 2003), (Hidayat & Egbu, 2010), (Mesurier, Rotimi, & Wilkinson, 2006)
Communication Opportunities	(Rotimi, Wilkinson, Zuo, & Myburgh, 2009) (Hidayat & Egbu, 2010).

CHALLENGES IN PDR PROJECTS

Reconstruction is comparatively riskier than usual construction projects, especially due to the problems in the risk assessment and planning process (Haltenhoff, 1999). Table 3 has summarized the key challenges identified through the literature.

Table 3: Challenges in a PDR Project

Factor	Sources
Risk assessment	(Haltenhoff, 1999)
Planning Process	(Chang, Wilkinson, Potangaroa, & Seville, 2011), (Schwab, 1998)
Lack of resource availability	(Nazara & Resosudarmo, 2007)), (Steinberg, 2007), (Zuo, Potangaroa, & Wilkinson, 2008),
Procurement	(Hidayat & Egbu, 2010), (Russell, 2005)
Economic situation	(Hidayat & Egbu, 2010)
Funding	(Hidayat & Egbu, 2010), (Freeman, 2004)
Environment	(Hidayat & Egbu, 2010)
Legislation and policies	(Zuo, Potangaroa, & Wilkinson, 2008)
Project management	(Hidayat & Egbu, 2010)
Construction conditions	(Oliver-Smith, 1990)
Political and social factors	(Johnson, 2007)

It can be seen that PDR projects need to be clearly defined, properly planned, and implemented in stages (Roosli, 2012). Therefore, PDR projects need to follow certain principles that provide flexibility and rapid responses to adjust for uncertain situations and their success. Within this context, the suitability of Agile principles for PDR projects is discussed.

AGILE PRINCIPLES

According to the Cambridge Dictionary (2009), the meaning of “Agile” is “able to deal with new situations or changes quickly and successfully”. Agility itself is defined by one of its creators as follows: 'An organization's ability to adapt effectively in a changing, unpredictable business environment (Dove, 1996). Further, Agile systems are those that can respond to both reactive and proactive needs when they are unpredictable, uncertain, and likely to change (Dove, 2005). Agility definition according to the management of the business is the capacity of the project team to adjust the project plan rapidly as a response to the needs, competition, or technology of consumers or stakeholders to achieve better project and product results in a creative and competitive project environment (Conforto, et al, 2016).

Table 4: Agile Principles

Principle	Sources
Flexibility and speed	Shine (2003); Stapleton & Consortium (2003); Boehm & Turner, (2004)
Smoothness and alertness	Erickson, Lyytine, & Siau (2005)
Ongoing rapid feedbacks	Kamat (2012)

Leanliness	Hansson, Dittrich, Gustafsson, & Zarnak (2006); Sanchez & Nagi (2001)
Continuous quality assurance	(Alleman, 2007)
Acceptability of changes	Fernandez & Fernandez (2008)
Continuous willingness to adopt	Goldman, Nagel, & Preiss (1995)

Principles of Agile has been evolved through the years and Table 4 summarized the key agile principles as per the literature review.

3. RESEARCH METHODOLOGY

This research intended to analyze the applicability of Agile principles for PDR projects. This requires obtaining the views and opinions of PDR projects, project management, and agile concepts. Due to the exploratory nature of the research, a qualitative approach was adopted with the use of expert interviews in the form of semi-structured interviews. Another major reason behind the selection of expert interviews was the “Agile” being a young concept in the Sri Lankan construction process (Pradeep, 2017). Ten (10) expert interviews were conducted among the managerial level staff such as project managers, project consultants, senior architects, quantity surveyors and engineers who have spent more than 10 years in the construction sector and have experience in PDR projects in Sri Lanka. The snowball sampling method was adopted due to the novel nature of the concept of “Agile” in the local context.

Semi-structured interview data were analyzed through qualitative data analyzing techniques. The content analysis method is initially used to analyze the data by coding word groups into categories (Perry, 2001). Thus, the study used manual content analysis for data analysis. The approach of manual content analysis is quite useful for making replicable and accurate interpretations from text to sense of usage (Krippendorff, 2004).

4. RESEARCH FINDINGS

INTERVIEWEE DETAILS

Table 5 illustrates the details of the interviewees of the research. Accordingly, the quality and the impact of the experience are shown with the data provided.

Table 5: Details of the interviewees

Interviewees	Designation	Related Region	Experience
I01	Senior civil engineer	Sri Lanka	More than 5 years
I02	Director	UK	More than 15 years
I03	Chartered Quantity Surveyor	Middle East	More than 5 years
I04	Senior Lecturer in Construction	UK	More than 10 years
I05	Quantity Surveyor	Middle East	More than 5 years
I06	Senior Lecturer in Construction	Sri Lanka	More than 8 years
I07	Senior Quantity surveyor	Sri Lanka	More than 5 years
I08	Chartered Quantity Surveyor	Middle East	More than 5 years
I09	Quantity surveyor	Sri Lanka	More than 5 years
I10	Procurement Specialist	Sri Lanka	More than 8 years

According to the interviewee details all the interviewees are having more than 5 years of experience. Furthermore, the interviewees are from different parts of the world illustrating the combination of experience related to different geographical locations. Additionally, the demography of the interviewees demonstrates that the research outcome is consisting of industry experience and academic knowledge.

SUITABILITY OF AGILE PRINCIPLES FOR PDR PROJECTS

The agile principles in the literature were tested under experts' opinions following the applicability of Agile concepts for PDR projects and combined with the primary data findings of the interviews.

Table 6: Characteristics of Agile Principles

Agile Principles	Characteristics/ Advantages
Team-oriented constructions	Easy to negotiate, easy to communicate, low disputes, reduce processing time, speed and flexible, negotiable, efficient, maintain good quality
Most suitable person	Value engineering, Fast identification of risks, Experience, Reduce processing time, Speed and flexibility, Reduce cost overrun, Efficient, Good negotiation
Time management	Pre-established land registry, reserved resources, digitalization, effective communication, pre-established potential contractor's registry
Rapid/ end-user feedback	Avoid variations, Efficient results, Maintain quality, and Opportunity to rebuild
Communication	Verble communication with conformation, written communication, Digitalization (Digitalized documents, Online meetings, Online purchases, Online bidding, BIM), Online meetings, Efficient when using a team-based approach
Section-wise/phase-wise/ element-wise procuring	Speed, resource shareability, effectiveness, resources management, cash flow management

Since the self-organizing team is a main concept of the Agile manifesto under team-oriented construction, Beck, et al. (2001) mentioned that team-oriented construction can be tested for the applicability of Agile concepts for PDR projects. This has been identified as a benefit and possible shortcoming of using the 'teams' concept within PDR projects. Further, according to I01, "*a team is a self-organizing unit of the Employer, the Engineer, and the Contractor, and other stakeholders where the leadership position of the team shifts often based on the requirements of the specific iteration. Moreover, instead of traditional sequence-based 44 construction by one construction team, this method facilitates few teams to work parallel on the same project ensuring a speedy construction process*". Also, according to I06, "*the end-user should be a sub-member of the group to review the final product compatibility. Concerning the suitability of the team-based concept for the PDR projects*", I10 acknowledged the appropriateness of it. I10 stated that "*Since team-based construction involves different teams who are experts in different working packages as civil and structural, electrical, mechanical, it helps to enhance the quality of output, speed of the construction in PDR*". According to I05, "*Working with a team always ease the active involvement and undertaking timely effective actions to reduce major risks*". Considering about team-based approach, I08 stated "*The team has different educational, experience level members, so they can use their knowledge and sharing knowledge among the team members and can make good products and associate with risks*". I09 pointed out that important characteristics of team members stating that "*mutual understanding and proper communication should be within the teams to manage variation without any conflict*". Therefore, if the team-based approach is to be successful in PDR, proper communication and coordination within teams should be there. The most suitable person is the most experienced, knowledgeable, and potential person within the scope of work. Transferring the leadership of management of risks to the most suitable person in a PDR project is the best option. Findings supported the risk transfer method and suggested alternative options regarding the most suitable person.

Considering the experts' ideas about the most suitable person for the project team, "*Assigning the most suitable person to handle the project is very important due to the complex nature of the PDR project*" stated I07. The importance of the experience of the most suitable person is pointed out by I03 stating "*Most suitable person means the most experienced and qualified party. Therefore, transferring risk to that party helps to identify all sources of risk and major risk early as possible and respond with effective migratory actions*". The main risks are unforeseen physical conditions, inflation after a massive disaster, rapid design changes, and environmental conditions. With expert opinions, the risks can be identified in the pre-construction stage and can allow a sum for the risk and reduce the risks by tests and add a win-win situation for the parties of the contract. The sum can be used when the situation occurred, or the sum can be divided among parties or used for another work according to negotiation in the pre-stage. According to I03, "*Conduct proper damage analysis and set up the scope of work along with that to produce more effective output for the PDR project, properly planned construction program, provisional money allocation for cover contingencies*" Also, I05 stated a similar statement about the management of risks; "*Getting proper test report before starting the project. E.g., Soil investigation reports, weather forecast reports, well-planned construction master plans, and provisional money allocation for unforeseeable works. But those are extremely difficult in PDR projects with the period and budget*" However, I04 pointed out "*a critical issue that most suitable person should experience complying with the PDR environment, regional environment, understanding about the cultural aspects of the disaster victims and should be updated otherwise the experience may not assist the risk management*". According to the I10, "*the personal abilities of team members might be affected rather than experiences, therefore, sometimes a person with good abilities with experienced guidance will be effective for the management*".

Under time management time is a valuable factor considering the PDR projects. Due to the construction rush of all PDR projects, proper management is needed to stay on time, especially on the construction plan. The time management concept can be achieved in various ways. I01 explained time management explaining "*post-disaster reconstruction should be finished without any time extension. therefore, each party should identify the upcoming situations that directly affected the time extensions. With a better plan and emergency protocol for the reconstruction, the time extension can be reduced in the predevelopment stage*". According to I03, "*Identify the most earlier requirement of the Most Suitable Person Value engineering Fast identification of risks Experience Reduce processing time Speed and flexible Reduce cost overrun Efficient Good negotiation 50 projects with proper planned construction master plan, and proper procurement plan to minimize insufficient imported material, equipment, machinery at the site, therefore, better commutation with package contractors in the project, leads to successful PDR project time management*". According to I08 well-developed technologies can reduce the time in PDR. I10 stated that "*Digitalization of documents and communication will accelerate any project in procurement stage*". I02 stated that "*maintaining a database of land, material, labour and equipment, preselection of contractors, maintain a framework for reconstruction will reduce the need of completing the PDR in a hurry*". However, I04 stated, "*Accelerate of a reconstruction project in the pre-construction stage can never be done until shifts from the firefighting approach, matured intention of reconstruction and planned framework for reconstruction in a country*". According to I02, "*pre-established databases are a good opportunity for time management. Other experts have also stated their opinions about the pre-established database of contractors, labour suppliers, and a registry of potential land*". I10 stated the state's contribution to the databases.

Since customer satisfaction and rapid feedbacks are the main concepts of the Agile manifesto, (Beck, et al., 2001) those principles can be tested as the applicability of Agile concepts for PDR projects directly. The Importance of getting feedback is pointed out by I10 stating, "*Feedback and suggestions are the keys to success in every organization or project. Unfortunately, this feedback is rarely collected and followed by construction stakeholders these days*". However, in a normal situation, feedback is collected after the total work is done. Complying with the Agile concept, the suitability of rapid feedback for PDR projects is discussed with the interviewees. Since changes in scope and variations are essential factors that often serve as challenges for PDR projects, especially focused on how rapid feedback from the employer on the changes in scope is helping the efficient progress of the PDR projects. According to I03, "*Generally in construction contract contractor is bound to execute variation*

orders before receiving taking over the certificate of work. Therefore, the employer has the right to change the design as per his requirement through variation order". Then a similar statement stated by I05 explaining the process. "Rapid feedback from employer ensures quick responses to the changes which occurred during the construction stage. E.g., Variation orders". I08 stated the benefits of using rapid feedbacks from the employer stating, "Can maintain quality, cost and time with rapid feedback and responses". However, I09 stated the drawbacks of rapid feedbacks stating "For identify the mistakes and new opinions give the best product with the best quality. Sometimes it affected the cost overrun and delay the project". In I04's opinion, it's impossible to work with rapid feedback from an employer in a practical scenario. The suitability of the end-user's feedbacks for the PDR projects was discussed. Most of the interviewees' opinions were it's positive to use end users' feedback. According to I10's opinion, not only end-users but also the neighbours' feedback on which the reconstruction is willing to proceed is vital. According to I01, "The PDR projects are a great opportunity to rebuild the country, Therefore PDRs can be built with the end-user opinions. Then, no need to rebuild the project for the long term, and the satisfaction will be high" Also, I03 supported it by stating "End users are the beneficiaries of the project outcome and utilizing functions. Therefore, getting their opinions lead to fulfilling the original requirements". According to I05, In Sri Lankan PDR projects which couldn't reach ultimate success such as apartment projects for flooded victims at Kelaniya and Tsunami villages in the Southern area could achieve ultimate success through end-user feedback before construction.

Better Communication is a critical factor for time management, the decision-making procedure of a project, and ultimately the speed of the project. According to I05 "Face-to-face communication is quick but keeping document-based written records avoids conflicts". I03 had the same opinion about the face to face communication. I01 supported the argument by stating "Face-to-face communication is easy, but the proper documentation is critical to the disputes and arbitration". According to I09, "verbal Rapid/ End-user Feedbacks Avoid Variations Efficient Result Maintain quality opportunity to rebuild communication is quick but need proof such as verbal confirmation orders for contract uses.". I04 stated that "stakeholders' intention to the project is more important than communication method, However, verbal communication is a good practice. Considering the written documentation, it's time-consuming. The ultimate objective of the communication should be the success of the project, not the willing disputes still not happened". Further, I02 stated "Rapid meetings with a team suggested before for feedback, progress, and discuss the issues will be the best solution for the communication. However, it's essential to keep meeting minutes up to date". However, according to I06, "Still the written communication is secure with the claims and dispute resolution process". As an alternative way, I07 and I10 suggested using electronic media to communicate with the stakeholders, However, due to digitalization is comply with Agile concepts, the suitability of online communication methods such as Zoom, Microsoft Teams, and Skype was argued in the interviews, Interviewees has pointed pros and cons about using the online method for communication and solution for minimizing the effect of those problems. according to I01, "Connection errors, especially after an environmental disaster, will happen, Also the lack of resources and knowledge about modern technology is critical. Through proper training, and backup connection methods the issues can be overcome". I05 stated that "Sometimes technical disruptions can ruin discussion outcomes. Lack of knowledge of online sources also is a problem. To minimize those problems employers can introduce training programs and IT specialists can be hired".

As an Agile principle, cited by Gajendran, MacKee, and Brewer (2011) a PDR project can divide into small packages and the procuring can be done according to those small packages. However, according to experts' opinion, a common practice is all the sections, phases, or elements are done by one contractor or a few contractors in a sequencing method due to the funds available for the PDR project. Table 6 shows the key benefits of using a section/ element and phase-wise procuring. According to I03 "Elemental/sectional wise procuring is a speedier construction method. Since several phases are undergone by the different entities of constructing parties each section can be built at I same time without inadequate employees and machinery. Otherwise, one single contractor may not be equipped with required manpower (labours, professionals), machinery, and equipment to start several packages at the same time". Also, I05 supported stating. "Elemental wise procuring is more effective because several phases can be built parallelly and the same time evaluation of each phase progress also easy.

During the construction stage, resource management, and personal management can arrange properly, also It avoids task conflicts”. However according to I10, “that might reduce the time but fund allocation for the projects may happen.” I08 had the same opinion about the section, element, phase-wise procuring. according to I02, “*there might be bulk works assigned for a specialist at the same time, therefore, they might not be able to manage their works*”. However, according to I06, section-wise, phase-wise, and element-wise procuring are three different methods, and they should be used after a proper assessment of PDR nature. Each method has benefits and drawbacks. In brief, each method should be adopted after a proper assessment. As an alternative way was identified by the discussion with I04 “*instead of the section, element, and phase-wise procuring, the functional unit-wise procuring is more effective. It’s easy to manage the supply chain too at a low cost*”. I01 pointed out a critical point about those methods.

Arbitration and dispute resolution were pointed out significant time during the interviews. Therefore, the suitability of Agile concepts such as self-oriented teams for arbitration and dispute resolution was discussed during the interviews. according to I01, “*Basically it's easy with a small team to dispute resolution. But every team member has a huge responsibility and represents a massive party*”. I08 and I09 also supported that a small team is more suitable than a massive team considering dispute resolution. However, according to I07, “*It is not easy and time-consuming. Adopt negotiation or mediation is the better practice*”. According to I04, “*disputes resolution is not valid between teams. It can occur only between two main parties of the contract; therefore, it should be negotiated between the teams instead of dispute resolution.*” according to I02, a member of a small team has influencing power than a massive team. therefore, the probability of wrong decisions acting is affected due to the small number of team members. Section/ Element / Phase wise procurement Speed Resource shareability Effective Resources management cash flow management as discussed in the previous section, scope changes and variations have a significant influence on PDR projects. Considering alternative ways for variation according to I02, and I06 proper planning can avoid most variations., Using BIM and other 3D simulations are good practice for reducing PDD, according to I08, “*Using new technologies such as Primavera, unifier, for project planning and digitalization will reduce variations*”. According to I01, “*With the Contractor’s involvement in the pre-development stage, variations can be limited, but urgent and immediate variations can be processed through negotiations between parties bypassing the variation procedure*”. Considering Agile practice I07 suggested, “*Give authority to generate necessary variation at the site level for relevant team members*”. However, I02 stated that “*Pre-plan of the construction is the way to reduce a variation, but it is hard to do with a PDR rush. Pre-agreed procedure for quick variation in the contract will be the answer for the rush*”. Further, I10 stated that “the contractor and client should have complied with other parties’ opinions in variation and value management process.” Therefore, according to those opinions, the variation can be managed with proper negotiation. As an Agile concept, the team-based approach will be a great opportunity to reduce variation.

NON-COMPLIANCE FACTORS OF AGILE PRINCIPLES

However, according to the findings, there are a few non-compliance factors in Agile concepts in the Sri Lankan context as well.

Figure 2 has illustrated the noncompliance in Agile concepts related to PDR projects. The outcome demonstrates the combination of findings from the secondary and primary information. Therefore, the noncompliance of agile principles is consistent with the different principles and human-related features. Additionally, economic concerns, practical issues, and

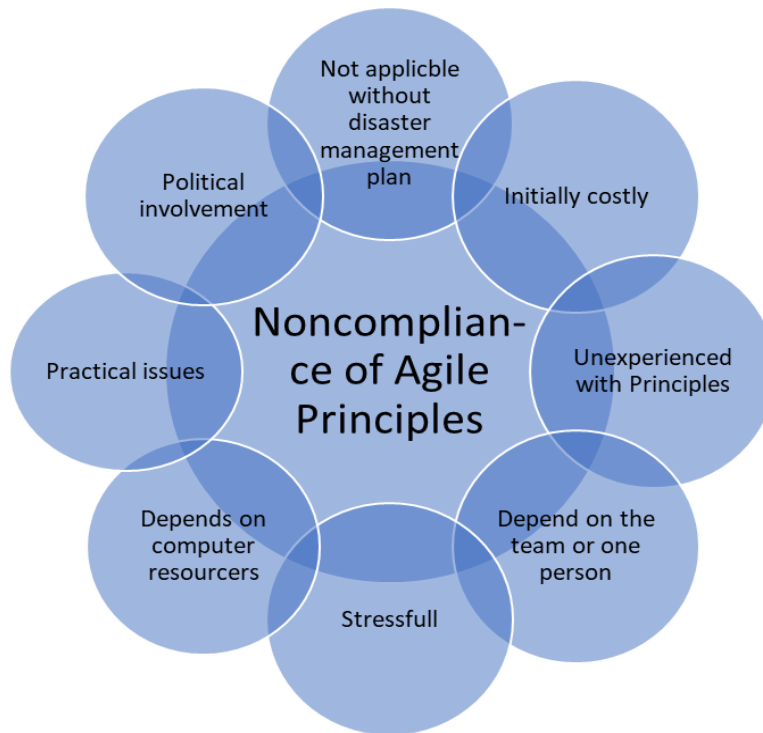


Figure 2: Noncompliance of Agile Principles to PDR Projects

OVERCOMING PDR CHALLENGES THROUGH AGILE PRINCIPLES

Table 7 shows a summary of findings achieved through literature and primary data on how to overcome reconstruction challenges through Agile principles.

Table 7: Suitability of Agile Principles to PDR Projects

Disaster and reconstruction challenges and characteristics	Construction problems	Agile principle	Comments
The dynamic and complex process	Risk management	Transfer risk to the most suitable party.	The most suitable party can handle the risk, more effectively than the traditional process. Based on the
Low resources availability, Less bulk production of the resources,	Contracting and availability of suppliers	Flexibility and rapid responsiveness, reduce wastage	The most suitable supplier can be found with flexibility and if not available, rapid contracting can be done for the different contractors, from time to time.
Social, and political-economic problems	Changes in the scope of the project	Flexibility and small team-oriented methods, rapid responsiveness	Contract, the scope can be adjustable in low-cost variations than traditional methods

Legislation and regulation	Time-consuming	Repetitiveness speed, and digitalization (documents and bidding)	With speed and digitalization, time can be managed more than conventional methods, low need for paperwork required
Planning	Time-consuming and low professional availability	Small team-oriented methods, rapid responsiveness	Change of plans can be rescheduled in a small period reducing the decision taking time.
Quality problems	Quality assurance	Responding to changes and customer collaboration, taking feedback	Quality can be assured by Feedback and quality changes can be achieved by rapidly responsive
Funding	Cost control	Digitalization, negotiation, ethics	The limited cost can be managed through digitalization and negotiation with good ethics
Environment and construction conditions	Design risk and construction risk	Leanliness, adaptive to the environment, rapid responses, and small team	Quick adoption of the small team can reduce risk and risk divided into small teams

5. CONCLUSIONS

Post-disaster Reconstruction (PDR) is known as a major disaster management activity, which is more challenging than regular construction projects throughout the process. With the success of PDR projects in developing countries like Sri Lanka, the applicability of new principles to PDR projects should be tested for sustainability. It is the most suitable place to test the Agile concept under an uncertain situation like PDR projects than regular construction projects.

Flexibility and speed, smoothness and alertness, ongoing rapid feedback, leanliness, quality assurance and acceptability of changes were identified in the literature as key Agile principles. Agile themes such as “Team-oriented methods, Assign the most suitable person as risk handling party, Rapid responsiveness, End-user feedbacks, Time management, Modern communication, and Section-wise procuring” which were derived from the literature were tested for applicability of Agile principles in the local context. Primary findings, which are compatible with literature findings, further revealed that speed, resource shareability, resource management, cash flow management, efficiency, sustainability, time management, flexibility, reduced variations, client satisfaction, quality assurance, reduced cost overruns, negotiability, low disputes and reduced waste as key benefits of adopting Agile principles for PDR projects in Sri Lanka. The requirement of a disaster management plan as a prerequisite, high initial cost, lack of knowledge and experience, high dependability on computer resources and political involvement are identified as challenges to be addressed in applying Agile principles in the context of Sri Lankan PDR. However, as per the findings, the applicability of Agile principles in Sri Lankan PDR is well established due to the inherent benefits of Agile principles in resolving the prevailing problems in disaster reconstruction projects in Sri Lanka. The findings provide the basis for the research on the development of a mechanism to develop an agile principle-related framework to create an effective PDR process in Sri Lanka. Furthermore, the findings support the identification of the importance and involvement of stakeholders and resources in the PDR.

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**COST OF CONSTRUCTION UPDATE FOR THE YEAR 2022:
POSITION OF SRI LANKA (COLOMBO) WITHIN THE SOUTH ASIAN
REGION**

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COST OF CONSTRUCTION UPDATE FOR THE YEAR 2022: POSITION OF SRI LANKA (COLOMBO) WITHIN THE SOUTH ASIAN REGION

ABSTRACT

Sri Lankan construction industry contributes around 7-8 percent to the Gross Domestic Product (GDP) of the country. Even though construction activities often act as a reliable bellwether for economic performance of a country, the construction industry demand is fluctuated due to several factors. The Easter Sunday bomb attack, COVID-19 pandemic and economic downturn with political instability occurred in Sri Lanka within the period of 2019 - 2022 have adversely impacted the demand for construction. The said instabilities and resultant debt crisis have become critical factors which have negatively impacted the demand for construction. This study is to provide more cognitive information on the update of cost of construction in Sri Lanka with year 2022 data.

Keywords: *Cost of Construction, Covid 19 pandemic, Demand, Economic downturn*

1. INTRODUCTION

This article updates the technical paper published for the year 2018 in Focus Journal, Volume 10: Issue-01, March 2020 published by Institute of Quantity Surveyors, Sri Lanka, revising the published data of the article “Cost of Construction – Position of Colombo, Sri Lanka within the South Asian Region.” with the information for the year 2022. Notably, the COVID-19 pandemic and economic downturn with political instability occurred in Sri Lanka within that period. The said instabilities and resultant debt crisis pushed the country to an economic crisis and then to the extent of declaring bankruptcy. Accordingly, the construction industry also went into a crisis. The year-on-year contraction recorded in the construction industry from 2021 to 2022 is 20.9% as per the Central Bank Annual Report of Sri Lanka 2022.

In June 2023, with the International Monetary Fund’s debt restructuring programme, there is a slight improvement in tourism, some increase in foreign workers’ remittances to Sri Lanka, no considerable fuel shortages and no power cuts. However, the demand for construction and investor confidence is still weak as the substantial contraction of 20.9% may take a reasonable recovery period.

2. METHODOLOGY

This article represents the data selected from the typical constructions of the below categories and converted to a single currency of US\$, enabling easy understanding and visualising. However, a change in the exchange rate makes a huge difference. If the particular currency is strong compared to the base currency, the cost of construction will appear high.

1. Residential
 - a. Townhouses medium standard
 - b. Apartments high-rise
2. Aged care / affordable units
3. Warehouse/factory units – Basic
4. Hotels
 - a. 3 Star travellers
 - b. 5 Star Luxury

Moreover, the following cost elements have been excluded from unit rate calculations to make a uniform basis for comparison.

1. External works,
2. Landscaping,

3. Demolition,
4. Loose furniture,
5. Fittings and equipment,
6. Professional fees,
7. Legal and finance fees, and
8. Soil investigations.

The costs of construction in different cities in the South Asian region except Colombo were obtained from the International Construction Market Survey 2022 published by Turner & Townsend, Construction Market Update 2022 by Rider Lever Bucknull, and Construction Cost Handbook published by ARCADIS. The cost of construction in Colombo was prepared using the historical cost data available with the authors.

3. DATA ANALYSIS AND PRESENTATION

Tables 1, 2 and 3 below provide updates on the cost of construction in 2022 of various cities in Asia for the different building types. The construction costs of different cities have all been converted to US\$. to enable comparison.

Table 1: Costs of construction (Residential) in US\$ per m² and their rankings in ascending order

City /Country in the South Asian Region	Apartments high-rise		Townhouses medium standard	
	Cost (US\$)	Rank	Cost (US\$)	Rank
Mumbai	658.80	1	448.00	2
Shanghai	725.40	2	701.80	5
Ho Chi Minh City	741.50	3	485.00	3
Jakarta	1,009.90	4	592.00	4
Kuala Lumpur	1,122.50	5	302.50	1
Colombo	1,250.01	6	750.00	6
Manila	1,970.50	7	1,054.00	7
Singapore	2,215.80	8	2,363.50	8
Hong Kong	4,085.60	9	4,468.60	9
Tokyo	5,107.40	10	4,118.90	10

Source: Turner & Townsend: International Construction Market Survey (2022), Rider Lever Bucknull: Construction Market Update 2022 & ARCADIS Construction Cost Handbook (2022)

Table 2: Costs of construction (Industrial/warehouses) in US\$ per m² and their rankings in ascending order

City /Country	Construction Cost (US\$)	Rank
Ho Chi Minh City	416.50	1
Kuala Lumpur	497.50	2
Colombo	520.70	3
Shanghai	630.80	4
Mumbai	658.80	5
Manila	832.00	6
Jakarta	1,567.10	7
Singapore	2,880.60	8
Hong Kong	3,574.90	9
Tokyo	4,530.80	10

Source: Turner & Townsend: International Construction Market Survey (2022), Rider Lever Bucknull: Construction Market Update 2022 & ARCADIS Construction Cost Handbook (2022)

Table 3: Cost of construction (Hotels and Resorts) in US\$ per m² and their rankings in ascending order

City /Country	3 Star travellers		5 Star Luxury	
	Cost (US\$)	Rank	Cost (US\$)	Rank
Mumbai	856.40	1	1,119.90	1
Jakarta	940.30	2	1,556.60	3
Shanghai	1,017.20	3	1,892.40	4
Colombo	1,017.45	4	1,325.25	2
Kuala Lumpur	1,275.00	5	2,310.00	7
Manila	1,374.50	6	1,863.50	5
Ho Chi Minh City	1,596.50	7	1,994.00	6
Singapore	3,028.30	8	3,840.80	8
Hong Kong	4,213.20	9	5,362.30	9
Tokyo	5,148.60	10	7,208.10	10

Source: Turner & Townsend: International Construction Market Survey (2022), Rider Lever Bucknall: Construction Market Update 2022 & ARCADIS Construction Cost Handbook (2022)

Table 4 gives updates for the overall cost of construction of each city as the mean value of the costs of construction of the different categories of buildings.

Table 4 Overall cost of construction in US\$ per m² and their rankings in ascending order

City (Country)	Construction Cost (US\$)	Rank
Kuala Lumpur	946.94	1
Mumbai	720.78	2
Ho Chi Minh City	948.56	3
Shanghai	961.98	4
Colombo	972.63	5
Jakarta	991.68	6
Manila	1,313.78	7
Singapore	2,486.06	8
Hong Kong	4,042.00	9
Tokyo	4,128.10	10

Source: Turner & Townsend: International Construction Market Survey (2022), Rider Lever Bucknall: Construction Market Update 2022 & ARCADIS Construction Cost Handbook (2022)

4. DISCUSSION AND CONCLUSIONS

According to the costs of construction in Sri Lanka for the Year 2022, as detailed in Section 3, there had been a sharp increase in construction costs due to the economic crisis in the country due to import restrictions, resultant material shortages, fuel price hikes, and substantial increase of freight charges. Hence, the prices of a large variety of materials in December 2021 went up by more than 100%, and in the latter part of the Year 2022, some materials went up by more than 200%, such as glass, steel products, and PVC products.

On the other hand, the countries in the region have been recovering from COVID-19 and have shown some positive economic growth. This construction cost comparison shall be understood in that context.

Even in such adverse conditions, the Sri Lankan construction cost remained competitive as per the above information. The construction cost in Colombo is the fourth lowest in the South Asian region (Table 4). Even though the Sri Lankan construction industry primarily consists of significant imports for building services trades and new technologies, the Colombo construction prices became comparatively higher than in Mumbai, Jakarta and Ho Chi Minh City. The import dependency is comparatively low in those countries than in Sri Lanka due to the possession of many raw materials. Those economies are much more integrated with the global supply chain as well when compared to Sri Lanka. That could be a reason for the comparatively low construction costs recorded in those countries.

In order to reduce the costs of construction in Sri Lanka, it is required to get integrated into the global supply chain to make value-added products in the country and innovate suitable local materials to reduce the import component. In addition, waste minimisation, use of recycled materials and productivity improvement must be implemented.

Overall construction cost increase is now contributed by the VAT 15% and the cascading effect of the Social Security Contribution Levy (SSCL) through the entire supply chain. As per the authors' practice experience, the aggregate impact may be about 6%, the high-interest impact of about 8%, corruptive and tardy systems would impact about 5%, and inefficiency about 5%. These are totaling 24% except the VAT. Hence, proper research shall be conducted to find out the above percentages as the same are from the practice experience of the writers to have a general idea about the subject.

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**EXPLORING ENTREPRENEURIAL OPPORTUNITIES FOR QUANTITY
SURVEYORS IN SRI LANKA'S CONSTRUCTION INDUSTRY: A
COMPARATIVE STUDY OF STARTUPS**

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EXPLORING ENTREPRENEURIAL OPPORTUNITIES FOR QUANTITY SURVEYORS IN SRI LANKA'S CONSTRUCTION INDUSTRY: A COMPARATIVE STUDY OF STARTUPS

ABSTRACT

This study explores on startups and examines the business potential available to quantity surveyors in Sri Lanka's construction sector. 37 quantity surveyor entrepreneurs took part in interviews using a quantitative methodology to share insights into their experiences and success factors. Market demand, value-added services, innovation, networking, and specialized specialization all have promise, according to the research. Competition, economic uncertainty, and financial limitations are obstacles, though. This study highlights the importance of entrepreneurial activities in promoting economic growth and development in Sri Lanka's construction industry, providing quantity surveyors and stakeholders with useful information. To fully realize the potential of the sector, it is essential to comprehend these opportunities and obstacles.

Keywords: Construction Startup; Economic Revival; Entrepreneurship; Quantity Surveyors.

1. INTRODUCTION

The creation of jobs and the improvement of infrastructure are two major contributions made by Sri Lanka's construction industry to economic development. Given this situation, quantity surveyors have a tremendous opportunity to advance the field through entrepreneurial endeavors thanks to their distinctive combination of technical proficiency and business savvy. Quantity surveyors have historically been known for their work in cost estimation, contract management, and project management, but they are becoming more and more appreciated for their ability to lead business initiatives and commercial enterprises.

As it fosters innovation, job creation, and economic progress, entrepreneurship in the construction sector has been recognized as a catalyst for economic development (Karunasena & Pathirage, 2016; Cattell & Verrall, 2019; Smith, 2018). To maximize their business savvy and commercial management abilities, quantity surveyors must therefore comprehend the entrepreneurial potential offered in Sri Lanka's building industry. This study compares successful startups run by quantity surveyors to pinpoint the critical elements that contributed to their success and reveal tactics for reviving the sector.

2. LITERATURE REVIEW

INTRODUCTION TO ENTREPRENEURSHIP IN THE CONSTRUCTION INDUSTRY

Due to its potential to spur economic growth, encourage innovation and provide job opportunities, entrepreneurship in the construction sector has attracted a lot of attention recently (Othman et al., 2019). Quantity surveyors can use this industry as a fertile ground to launch their own businesses by utilizing their special skill set and expertise in cost management, project management, and contract administration (Abdul-Rahman et al., 2021). Quantity surveyors can be instrumental in Sri Lanka's construction industry's economic revival and sustainable development through embracing entrepreneurship.

ROLE OF QUANTITY SURVEYORS IN ENTREPRENEURSHIP

2.2.1 FINANCIAL MANAGEMENT AND BUSINESS INTELLIGENCE

According to Sayed et al. (2020), quantity surveyors have the necessary business sense and financial management abilities to succeed as entrepreneurs in the construction sector. Their proficiency in managing budgets, analyzing project costs, and negotiating contracts gives them the fundamental abilities needed to launch and run prosperous businesses. Quantity surveyors have a thorough

understanding of project viability and construction economics, which enables them to see possibilities, assess risks, and make wise business decisions.

2.2.2 INNOVATION AND VALUE CREATION

To promote innovation and value development within the construction sector, quantity surveyors are essential (Abdul-Rahman et al., 2021). Their understanding of building products, technology, market trends, and customer needs enables them to spot market gaps and come up with creative solutions. Quantity surveyors can increase project outcomes, efficiency, and client value by implementing innovative procedures, methodologies, and sustainable practices.

FACTORS INFLUENCING ENTREPRENEURIAL SUCCESS

2.3.1 MARKET KNOWLEDGE AND NETWORKING

Quantity surveyors who are successful in their entrepreneurial endeavors must have a solid grasp of the dynamics of the construction business as well as strong networking skills (Sayed et al., 2020). Quantity surveyors can spot market insufficiencies and new market niches for business opportunities by keeping up with industry developments, legislative changes, and developing technology. Building trusting relationships with key players in the industry, such as suppliers, contractors, and architects, can lead to fruitful collaborations and business referrals that are essential for entrepreneurship success.

2.3.2 STRATEGIC PLANNING AND RISK MANAGEMENT

Effective strategy planning and risk management are essential for entrepreneurial success in the construction sector (Othman et al., 2019). Quantity surveyors must create thorough business plans that include growth goals, marketing strategies, and financial estimates. Sustainable growth depends on making strategic decisions that are informed by in-depth market research, competitor analysis, and consumer needs. A proactive approach to risk management, which includes recognizing, evaluating, and minimizing risks, is also necessary for overcoming the uncertainties and difficulties that come with being an entrepreneur.

CHALLENGES AND BARRIERS TO ENTREPRENEURSHIP

2.4.1 FINANCING AND CAPITAL INVESTMENT

Finding sufficient funding and capital investment is one of the major obstacles that quantity surveyors who want to become entrepreneurs must overcome (Abdul-Rahman et al., 2021). Their desire to become entrepreneurs may be hampered by limited access to finance sources and the substantial costs involved with starting and growing a new business. These obstacles can be addressed and the financial resources required for business growth can be provided by looking at other funding possibilities such as government grants, angel investors, venture capitalists, and strategic alliances.

2.4.2 REGULATORY COMPLIANCE AND CONTRACTUAL OBLIGATIONS

Quantity surveyor entrepreneurs must manage a variety of regulatory compliance requirements and contractual commitments because the construction business operates within a complicated regulatory environment (Sayed et al., 2020). Building codes, permits, licenses, and legal requirements must be complied with, which necessitates rigorous attention to detail and specialist knowledge. To ensure compliance and reduce legal risks, quantity surveyors must stay current with legislative changes, regulatory shifts, and industry standards.

2.4.3 MARKET COMPETITION AND INDUSTRY DYNAMICS

Quantity surveyors have difficulties because of market rivalry and industry dynamics in the highly competitive construction sector (Othman et al., 2019). To stand out from the competition and provide distinctive value propositions, quantity surveyors must consider established players, market saturation, and shifting industry trends. Quantity surveyors can differentiate themselves in a competitive industry

by creating a distinctive brand identity, employing successful marketing techniques, and building a reputation for providing high-quality services.

3. METHODOLOGY

Quantitative methodology approach was used in the research. 37 Quantity Surveyor Entrepreneurs participated in Semi Structured interviews for this study. In-depth information about their experiences, difficulties, solutions, and success factors was given in these interviews. The results of the interviews had also been supplemented by observations of entrepreneurial operations and document analysis. The interview profile is illustrated in Table 3.1.

Table 3.1: Interview Profile

Number of QS	Startup Type	How Long	Average Number of Employees
10	Construction Firm	3 years	6
7	Consultant Firm	2 years	4
11	Freelancer	4 years	3
9	Design & Build Firm	3 years	8

4. RESULTS & DISCUSSION

Most of the quantity surveyors who have participated in this research have completed their bachelor's degree and have some sort of experience working in a company. The following figure and table depict the opportunities and threats in running a startup or firm.

The findings of the research highlight both opportunities and threats faced by quantity surveyor entrepreneurs in running their startups or firms.

Opportunities

- **Market Demand:** There is a sizable need for quantity surveying services in Sri Lanka's construction sector, which gives numerous potentials for entrepreneurs to launch and expand their firms.
- **Value-Added Services:** Quantity surveyors can position themselves as crucial partners for building projects by providing value-added services including cost estimation, project management, and procurement knowledge.
- **Innovation and technology:** By embracing technical improvements like project management software and Building Information Modeling (BIM), quantity surveyor entrepreneurs can streamline operations, increase accuracy, and provide services more effectively.
- **Networking and Collaborations:** Building strong networks and partnerships with industry players including developers, contractors, and architects creates opportunity for collaboration, knowledge sharing, and future commercial prospects.
- **Niche Specializations:** In the construction business, quantity surveyors can spot and focus on specialist regions that serve particular market niches or particular project requirements.

Threats

- **Competition:** There is fierce competition in Sri Lanka's quantity surveying market, where reputable companies and skilled workers are already active. It may be difficult for new business owners to draw in customers and build a reputation.
- **Economic Volatility:** It might be difficult for new businesses to retain a steady clientele when the economy and the construction sector are both fluctuating.

- Financial constraints: It can be a problem for quantity surveyor entrepreneurs, especially when it comes to obtaining finance and controlling cash flow in the beginning stages. Starting a new business or maintaining a startup involves an initial capital expenditure.
- Skill and Knowledge Gap: It takes more than just technical know-how to create a successful startup. You also need business sense and entrepreneurial abilities. Entrepreneurs in the field of quantity surveying may find it difficult to acquire these extra skills necessary for managing their businesses.

5. CONCLUSION & RECOMMENDATIONS

The research investigated the experiences, difficulties, strategies, and success factors of numerous companies managed by quantity surveyors using a comparative study approach. The results showed that given their roles in cost estimation, project management, and procurement, quantity surveyors have valuable skills and expertise that can be used for entrepreneurial endeavors. The comparison analysis made it possible to distinguish between several startup kinds, such as construction companies, consulting firms, independent contractors, and design and build enterprises, each of which presents certain characteristics and difficulties.

Several recommendations can be made based on the research's findings to assist and improve the business opportunities for quantity surveyors in Sri Lanka's construction sector. In order to provide aspiring quantity surveyors with the requisite business knowledge, money management abilities, and entrepreneurial attitude, it is imperative to include entrepreneurship-focused education and training programs inside the quantity surveying curriculum. Collaboration and networking are also very important, which is why quantity surveyors should actively participate in industry gatherings, groups, and platforms to forge lasting relationships with key players and consider joint venture opportunities. It will be easier for quantity surveyors to expand and thrive if financial literacy among them is improved and finance assistance systems created especially for quantity surveyor startups. It can also improve efficiency and value-added services to embrace technical developments that are pertinent to the area, such as BIM, cost estimation software, and project management tools. Last but not least, promoting beneficial laws and rules, such as expedited licensing procedures and rewards for sustainability and innovation, would foster a favorable business environment for quantity surveyors.

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**COST CONTROL STRATEGIES FOR THE FREQUENTLY HAPPENED COST
OVERRUNS CAUSED TO SME CONTRACTORS IN BUILDING
CONSTRUCTION PROJECTS.**

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COST CONTROL STRATEGIES FOR THE FREQUENTLY HAPPENED COST OVERRUNS CAUSED TO SME CONTRACTORS IN BUILDING CONSTRUCTION PROJECTS.

ABSTRACT

Small and Medium Enterprises (SME) contractors represent a prominent domain of the construction industry. With its own limited capabilities, being able to survive during an economic crisis is an extreme challenge for SME contractors. Although time, cost and quality lie at three corners of the successful project completion triangle, cost has been the main concern, especially among SME sector. Due to the availability of limited resources within SME contractors, having a meticulous understanding on managing cost overruns is essential. However, with the lack of reliable literature, it hinders the awareness of its' significancy and appropriate adoption within the practice. Therefore, this paper is in attempting to produce a collective body of knowledge in the arena of the ways of SME contractors could overcome the cost overruns. Initially, the critical and most popular, ways of cost overruns were derived from the existing literature that has been established for other industry contractors. The listed cost overrunning categories are poor planning and scheduling, inaccurate cost estimations and budgeting, scope changes, unforeseen site conditions, price fluctuations, poor site management and supervision, not hiring the right team, inadequate risk assessment and improper communication and collaboration. The closely overlapped factors are grouped together. Later, 28 strategies were proposed for 9 categories. It is well acknowledged that, the implementation and adoption growth of these proposed strategies would vary upon each contractors' strength and weaknesses. However, the findings do not limit the broader application among the industry practitioners which benefits the society at large.

Keywords: *Building Construction, Cost Control, Cost Overrun, SME Contractors, Techniques*

1. INTRODUCTION

The Small and Medium Enterprises (SME) in construction industry is a vital pillar of Sri Lanka's economy, providing employment opportunities and contributing to the development of the country's infrastructure and built environment (Cooray et al., 2018). Effective cost management is critical for the success of SME contractors in Sri Lanka, as it helps them optimize the use of limited resources, remain competitive in a highly competitive market, and ensure a long-term financial sustainability (Kulasinghe et al., 2018). Further, they have mentioned that, poor cost management can result in financial losses, project delays, low-quality work, and reduced profitability, harming the reputation and viability of SMEs. On the other hand, cost, time, and quality controls are the three main management tools that need to have the control over in construction projects in achieving a successful completion (Malkanathi et al., 2017). Owing to the limited financial and human resources in SME sector, cost factor has become prominent when compared to the other two factors.

This was further established by Kawmudi (2020) stating that, cost overruns can have significant impacts on SME contractors in Sri Lanka, as they may not have significant financial resources to cover the extra costs, leading to difficulties in paying suppliers, staff, or subcontractors, affecting sustainability. Additionally, cost overruns can result in reducing profitability, making it difficult for SME contractors to grow or expand their business, reducing investment in new equipment, technology, or training, and thereby, decreasing the competitiveness (Ramawickrama, 2016). In some cases, cost overruns can result in lower quality work, harming the contractor's reputation and long-term viability. Therefore, it is crucial for SME contractors to effectively control costs and mitigate the risks of cost overruns to ensure long-term sustainability and success. Despite the identified reasons and techniques, some SME contractors are still facing significant challenges in surviving the market fluctuations.

Therefore, it is important to be vigilant on strategies that can be accommodated within the organization. Through this article, an insight on possible strategies that SME contractors could utilize in the future adoptions will be presented.

2. SME CONTRACTORS AND COST OVERRUNS

The construction industry is consisting of complex projects, which is difficult in predicting the outcome at the beginning of a project. Currently, SME contractors undertake significant financial risks while contributing the sector's growth and play a vital role in ensuring the industry's sustainability (Malkanathi et al., 2017). Cost overruns are a significant issue in the Sri Lankan construction industry, affecting especially for SMEs owing to limited financial capabilities (Vaardini et al., 2016). As Kawmudi (2020) has illustrated that, contractors have to address this issue by careful planning, monitoring project expenses, and adapting budgets and timelines to accommodate unforeseen issues. Although they have presented the conclusion commonly to the industry, demarcation for the SME sector was not particularly addressed. As a result of the dynamic nature in the industry, facing uncertainties, making it is crucial to implement effective cost management approaches to minimize financial losses to stakeholders in every layer of the project. However, due to lack of knowledge of possible cost control techniques applicable to SME contractors, hinder the process.

2.1. REASONS FOR COST OVERRUNS

Though the reasons for cost overruns in SME construction contractors are not available in primarily, possible most popular reasons were brought up from other contractor perspectives. With the use of existing literature from various scholars, below list has made out the combination of all those findings together some of the key reasons: (Ellis, 2023: Jayathilaka, Waidyasekara and Sirimewan, 2021: Richer, 2020)

1. Inaccurate estimation and inadequate budgeting

Inaccurate estimations and inadequate budgeting are common causes of project cost overruns, causing delays, compromised quality, and financial shortages during construction.

2. Poor planning and scheduling

Poor schedules and planning lead to cost overruns, causing delays and costly mistakes.

3. Scope changes

Project scope changes result in additional resources, materials, and time, leading to increased costs and potential overruns.

4. Unforeseen site conditions

Unexpected site conditions such as soil quality, weather, and terrain can lead to additional costs that were not accounted for in the initial budget.

5. Price fluctuation and inflation

When there are rapid changes in material costs contractors may face higher procurement expenses that exceed their initial estimates. Additionally, inflationary pressures can impact labor wages and overhead costs, further contributing to cost overruns.

6. Poor site management and supervision

Inadequate monitoring and control of construction activities, including labor productivity, material waste, and equipment utilization, can lead to inefficiencies and increased costs.

7. Not hiring the right team

Incorrect employees on project sites can lead to inefficiencies and poor performance, both of which can impact on cost overruns.

8. Inadequate risk assessment

Failure to identify and address potential risks such as geological conditions, regulatory changes, or labor issues can lead to unforeseen expenses.

9. Inadequate communication and collaboration between project stakeholders

Effective communication and collaboration are crucial for avoiding misunderstandings, delays, and errors, ultimately reducing cost overruns.

2.2. TECHNIQUES FOR ADDRESSING COST OVERRUN

Since cost overruns are a significant challenge for SME contractors, to ensure project success, they have to adopt effective cost control techniques. The techniques that, involved in systematic cost management, identifying potential risks, and preventing overruns could have enhanced the cost management capabilities, minimized overruns, and achieved better financial outcomes in construction projects. Among the existing literature, various scholars have identified different techniques for reducing the impact of the above- mentioned causes of cost overruns, below listed of strategies are presented along with the scientific findings presented by various scholars: (Cooray et al., 2018; Frimpong et al., 2003; Gunawardhana and Vithana, 2020; Malkanthi et al., 2017; Santoso and Gallage, 2019). Further, the list is not exhausted with the scientific findings but also, discussed along with the authors' practical experience.

2.2.1. TECHNIQUES FOR REDUCING THE IMPACT OF INACCURATE ESTIMATION AND INADEQUATE BUDGETING.

The proposed techniques for reducing the impact of inaccurate estimation and inadequate budgeting can be list as follows:

- I. Conduct a comparative analysis using historical data - SME contractors can improve project estimation accuracy by analyzing past data and identifying similarities in scope, size, and complexity.
- II. Bottom-up estimation and use reliable tools - SME contractors can use bottom-up estimation by dividing projects into smaller components and calculating costs separately. Utilize specialized software or spreadsheets for efficient and error-free construction estimating.
- III. Regular updates and revisions of estimates - Regularly review and adjust the budget to reflect any changes in scope, market conditions, or other factors that may impact costs.

From the past data, organizations can track the cost overrun incidents within the organization and within different types of undertook projects. This would clearly represent a picture of the incurred expenditure over budgeted amount. Further, through a comparative analysis of cost overruns provide additional insights and valuable information about real cost behavior. Not only that, but also, it can be used in deriving future cost predictions and understand in future cost need. An overrun of budgeted amount is resulted because of either under budgeting of the expenditure or poor management of the cost allocation. With proper estimation tools and techniques, contractor can calculate budgets accurately. Regular maintenance and updates in the estimated costs should be closely monitored.

2.2.2. TECHNIQUES FOR REDUCING THE IMPACT OF POOR PLANNING AND SCHEDULING.

As a result of poor planning and scheduling, regardless of the project type, the impact is critical. Therefore, it is in need to mitigate the associated impact.

I. Develop a detailed project plan - Create a comprehensive project plan that outlines all the tasks, milestones, and deliverables required for successful project completion. Break down the project into smaller, manageable phases and establish realistic timelines for each.

II. Implement realistic and effective scheduling techniques - This technique allows contractors to prioritize tasks, identify dependencies, and allocate resources efficiently.

III. Regular monitoring and progress tracking – This includes monitoring task progress, identifying deviations, and taking corrective actions. Update project schedule and adjust resource allocation as needed.

Developing a detailed project plan won't forgone the delays occurring due to undefined or unrecognized events, which is followed by implementing realistic and effective scheduling techniques. This cause in improving the reliability of on-time completion of the project. Having said that, preparing an in-detail project plan compromise with a more reliable time frame. Moreover, the management of resources for each activity also can be accommodated within the detailed plan. Thus, SME contractors can utilize the limited resources more productively during each project and in between different projects. As above discussed, regular monitoring and controlling are indeed necessary, for an efficient practice. Implementing realistic and effective scheduling techniques is crucial for maintaining project timelines and minimizing cost deviations.

2.2.3. TECHNIQUES FOR REDUCING THE IMPACT OF SCOPE CHANGES ON COST OVERRUNS.

The impact of cost overruns from the scope changes can be reduced viz:

I. Impact assessment and accurate cost estimation - When a scope change is requested, conduct a thorough impact assessment to evaluate the implications on the project's cost and schedule.

II. Document and track all scope changes - Track scope changes' description, rationale, impact assessment, approval status, and track progress and associated costs throughout the project.

III. Negotiation and agreement with stakeholders - Engage in open discussions with the Employer and stakeholders to discuss scope change, ensuring fair cost management and negotiation.

Variations or scope changes are undeniable in construction projects. Impact assessment and accurate cost estimations are recommended techniques for reducing cost overruns caused by scope changes. Apart from that, documenting and tracking scope changes is important for maintaining transparency and accountability as an SME contractor. In addition to that, it aids in avoiding excessive costs and mitigating the risk on repetition of such works. Negotiation and agreement with stakeholders may not be a good strategy in overcoming the cost overrun every time. Yet, it's still possible to address it as an affected party because of the scope change. Unless value-engineered work proposals are also encouraged to sustain the project's feasibility.

2.2.4. TECHNIQUES FOR REDUCING THE IMPACT OF UNFORESEEN SITE CONDITIONS.

Here are some proposed strategies in overcoming the impact of unforeseen site conditions:

- I. Site investigation and assessment - Conduct a thorough site investigation and assessment before commencing construction, considering geological conditions, soil properties, underground utilities, and environmental constraints.
- II. Include contingency funds in the budget - Create a contingency fund in the project budget to cover unforeseen site conditions and cover potential costs.
- III. Develop prompt analysis and follow agile project management techniques - Assess and analyze unforeseen site conditions promptly to understand their impact on the project. Implement agile project management practices, emphasizing flexibility, communication, and iterative decision-making.

In most circumstances, the costs owing to an unforeseen site condition are claimed, the fact that it was beyond neither party's control. Although SME contractors are compensated for direct cost overruns, the possible linkages and indirect cost overruns may hinder the process and their capabilities in continuing the project significantly. Therefore, conducting a proper site investigation is recommended all the time to foresee future catastrophes. Upon such, a contingency fund allocation can be utilized and it can be considered as a proactive approach in mitigating the cost overruns due to the unforeseen site conditions. Even though contingency allocation improves financial flexibility, unnecessary allocations would drop the healthiness of the estimation. When an unforeseen situation arises, a prompt act is essential. Thus, the effectiveness of applying rigid waterfall project management principles during such a period of time, is a question.

2.2.5. TECHNIQUES FOR REDUCING THE IMPACT OF PRICE FLUCTUATION AND INFLATION.

Currently, price fluctuation has gained the spotlight within the construction industry market, owing to lack of following:

- I. Thorough market research and analysis - Perform market research to understand material and labor price trends, analyze factors influencing inflation, and monitor construction industry fluctuations.
- II. Establish strong supplier relationships - Establish reliable supplier-subcontractor relationships for competitive pricing and quality materials.
- III. Include price escalation clauses in contracts - Include price escalation clauses in contracts to account for inflation and price fluctuations, allowing clients to pass on cost increases or negotiate fair adjustments, reducing project budget impact.

After conducting comprehensive market research and analysis, it provides good insight into the future trends on market trends, possible impact and emphasizes pricing dynamics. The inclusion of price escalation clauses in contracts transfers the risk of price fluctuations to the Employer. Additionally, establishing strong supplier relationships advocates assisting in positive cashflow arrangements. Notwithstanding that, early procurement and long-term agreements also can be beneficial for SME contractors in terms of early security of materials at good prices, fixed price rates for a stipulated period and potential discounts depending on the situation.

2.2.6. TECHNIQUES FOR REDUCING THE IMPACT OF POOR SITE MANAGEMENT AND SUPERVISION.

Upon a failure of proper site management and supervision can cause significant problems. Therefore, it is necessary to maintain a sustainable practice in overcoming that.

- I. Strengthened site management and supervision protocols - Review and strengthen site management and supervision protocols to ensure they are robust and effective.
- II. Implement quality control measures - Establish a comprehensive quality control program to monitor and maintain construction quality throughout the project.
- III. Enhanced communication and training - Improve communication and training among site team and supervisors to ensure effective supervision of construction activities.

More importantly, SME contractors need to be aware of the successful site management and quality control measures. Implementing quality control measures reduces cost overruns caused by poor site management and supervision. Not only that, but also, addresses the other concerns related to health and safety, environmental protection, logistic management within the site etc. Strengthening site management and supervision protocols improves quality and vice versa. Enhancing communication and training facilitates the better performance of project work. Fragmented work relationships are not compatible with construction projects which have been widely represented as ‘Temporary Multi Organizations’ where good collaboration and coordination between each member matters a lot in achieving commonly established project aim.

2.2.7. TECHNIQUES FOR REDUCING THE IMPACT OF NOT HIRING THE RIGHT TEAM.

These techniques have been set for effectuating the suitable human resource in the project.

- I. Conduct a comprehensive assessment of candidates - Evaluate candidates through resumes, interviews, and references for construction project roles, ensuring a thorough evaluation and selection process, defining necessary skills and experience.
- II. Effective onboarding and training - Prioritize onboarding and training for team members to ensure knowledge and skills are fully developed.
- III. Regular performance evaluation and feedback - Implement a performance evaluation system for team members, assessing their performance against predefined criteria and project goals.

Human resource is another prime consideration that needs to focus on. By hiring the right team at the right crucial stages of the project ensure the project's stability, Conducting a comprehensive candidate assessment, secure the position where only competent working crowd is get hired. Effective onboarding and training accelerate the taking up cultural practices and organizational work systems for new team members. Regular performance evaluation, feedback, and swift identification of human resources are essential for continuous improvement and addressing any issue promptly. When it becomes evident that a team member is not the right fit for their role or the project, project management or the organization authority could act forward in handling the low labor productivity. Identifying performance issues, skill gaps, or misalignment with project requirements at the early phases of a project eventually, strategize the future implications. Both continuous performance evaluation and timely corrective actions in optimizing labor productivity to enhance project success.

2.2.8. TECHNIQUES FOR REDUCING THE IMPACT OF INADEQUATE RISK ASSESSMENT.

Inadequate risk assessment also would cause major deficiencies in construction projects specially.

- I. Comprehensive risk identification and conduct a periodic risk assessment - Implement a comprehensive process for identifying and assessing project risks at construction stages, regularly reviewing, and updating the risk register to address new and existing risks.
- II. Establish a risk monitoring and review process - Implement a system for ongoing monitoring and review of project risks.
- III. Contingency planning - Create comprehensive contingency plans to address identified risks, defining actions and resources needed to mitigate their impact.

Lack of risk assessment sets a solid foundation in incurring cost overruns. Comprehensive risk identification and periodic assessment are usual mandates in controlling the known unknowns in a construction project. Adequate risk assessment paves the pathway of achieving sustainable construction project completion. With the use of thorough risk identification and assessment in a project, unnecessary costs can be omitted and optimized viz either mitigating or avoiding risk. It is acknowledged that, through a continuous risk monitoring and review process, proactively managing the risks is possible and thereby allocating equivalent cost also can be controlled within the margin.

2.2.9. TECHNIQUES FOR REDUCING THE IMPACT OF INADEQUATE COMMUNICATION AND COLLABORATION BETWEEN PROJECTS STAKEHOLDERS.

Since a construction project has been considered as a temporary multi organisation, communication and collaboration have to be ran across the project duration to continue a smooth flow of work activities.

- I. Use of collaboration tools and technology - Utilize collaboration tools, technology platforms for efficient communication, information sharing, and centralization of project information and documentation.
- II. Stakeholder engagement and involvement - Actively engage and involve all relevant stakeholders throughout the project lifecycle.
- III. Regular project meetings - Conduct regular project meetings with stakeholders, including team, subcontractors, suppliers, and clients.
- IV. Clear roles and responsibilities - Clearly define and communicate the roles and responsibilities of each stakeholder involved in the project.

As mentioned in previous sections, construction projects are unlikely to be successful in a completely fragmented environment. Having good communication and collaboration is a must, since multi parties are working towards in fulfilling a shared goal. The engagement of every stakeholder is essential in both project work and organization work. Actively involving stakeholders in the decision-making process can lead to better organizational outcomes. The diversity of perspectives among the stakeholders opens up the various technical strategies that could contribute to successful project execution. Regular meetings and clear roles and responsibilities entertain the project participants up to date.

3. CONCLUSION

The paper presents the effective techniques to reduce cost overruns that SME contractors could utilize in adopting at the field. Adopting accurate techniques and implementing them at the right time is crucial for successful cost control. There are several current practices that contractors adopt to reduce and prevent cost overruns. Each specific cost overrun reason is addressed by multiple techniques. These diverse techniques and practices reflect the multifaceted nature of cost overrun challenges in building construction projects and highlight the proactive approaches that could have been taken by SME contractors to mitigate and prevent such issues. The proposed strategies guide better cost management and ensure successful project completion within budgetary constraints.

On the final note, construction cost overruns in projects can occur due to various reasons. To mitigate these, SME contractors should follow the proposed strategies to prevent overruns. This approach helps them effectively manage costs and complete projects without experiencing overruns. Prioritizing cost management is crucial for project success and profitability.

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DISPUTE AVOIDANCE STRATEGIES FOR SRI LANKAN CONSTRUCTION INDUSTRY PARTICIPANTS

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DISPUTE AVOIDANCE STRATEGIES FOR SRI LANKAN CONSTRUCTION INDUSTRY PARTICIPANTS

ABSTRACT

The construction industry involves multiple disputes due to its unique characteristics requiring proper dispute management practice. Hence, implementing dispute avoidance strategies is essential before advancing to the dispute resolution process following the concept of “prevention being better than cure”. Accordingly, there is a timely need to identify dispute avoidance strategies for the construction industry in Sri Lanka to guide its participants. The research adopted a survey strategy to collect quantitative data from a sample of 70 construction professionals selected using convenient sampling. Seventeen causes of disputes were ranked based on their impact on dispute occurrence and ability to avoid. Ultimately, 18 dispute avoidance strategies and their importance in avoiding disputes arising in Sri Lankan construction projects were identified to guide construction industry participants.

Keywords: Disputes; Dispute Avoidance Strategies; Construction Industry; Sri Lanka..

1. INTRODUCTION

The construction industry is an economic bellwether that makes an indispensable contribution to a country's GDP and is vital to achieving a country's national socio-economic development goals (Ribeirinho et al., 2020). Moreover, according to Yale (cited in Cheung and You, 2006, p. 456), projects with a highly complex, uncertain and long-term nature are bounded by project uncertainty and contractual problems. Therefore, conflicts and disputes are inevitable in the construction industry due to its inherent complex, unpredictable nature.

Disputes devastate successful project completion, resulting in cost overruns, time overruns, loss of productivity, wastage of resources, and yielding of parties' business relationships. (Sayegh et al., 2020). Changes frequently lead to contractor claims, and a certain number of changes are inevitable on a complex project, which may create disputes. A clear and comprehensive project scope definition before the start of detailed design avoids many changes and their impact on disputes (Gibson and Pappas, 2003).

Hence, a well-functioning dispute management practice is indispensable, including dispute avoidance, mitigation, and resolution processes in construction contracts (Sayegh et al., 2020). Currently, the construction industry is trying to grasp that “prevention is better than cure”. According to Zhu and Cheung (2020), even though construction projects are severely prone to unforeseen and unprecedented risks and challenges, proper contract administration is the most critical factor in dispute avoidance. However, the Sri Lankan construction industry still follows dispute resolution after occurring disputes. Hence, the Sri Lankan construction industry has a critical requirement to follow dispute avoidance practices rather than following dispute resolution processes. Thus, this study aims to guide construction industry participants with strategies to avoid disputes in Sri Lankan construction projects.

2. LITERATURE REVIEW

‘Conflicts’ and ‘disputes’ are two distinct notations used interchangeably, especially in construction. The construction industry has been a paradoxical leader in dispute occurrences and dispute resolution systems (Gebken and Gibson, 2006). The ‘conflict’ exists wherever there is an incompatibility of interest, and it is the prime drive for disputes (Cakmak and Cakmak, 2014). Hence, according to Cakmak and Cakmak (2014, p. 186), “Disputes are one of the main factors which prevent the successful completion of the construction project”. If the conflict has not been solved, it has become a dispute.

Conflicts between the client and contractor are inevitable due to the complexity and uncertainty of the construction projects. Negotiation occurs at every stage of conflict resolution, which may end up in an amicable way or intense and costly way, such as litigation (Lu, Zhang, & Pan, 2015). Negotiation costs for the conflicts include not only direct costs (e.g., money paid for lawyers) but also indirect costs (e.g., damage to the relationships, extra time devoted to conflict resolution) (Li, Arditì & Wang, 2012). Further, due to its unique characteristics, the construction industry has dealt with multiple disputes (Kolonne, 2012).

Alternative Dispute Resolution (ADR) is the universally acknowledged umbrella term for introducing various dispute resolution techniques outside the judicial process (Abeynayake & Weddikkara, 2013). According to the authors, negotiation, mediation, conciliation, neutral evaluation, and arbitration have been typically practiced as ADR methods.

However, now it seems that the construction arena is trying to grasp the concept of ‘prevention is better than cure’, which has been neglected in the past. In other words, rather than trying to resolve the disputes after the occurrence, the construction industry is keen to take measures to avoid or eliminate the conflicts to prevent the disputes from happening. Zhu and Cheung (2020) emphasized that dispute avoidance is preferred over deploying extensive resources to resolve disputes. Furthermore, dispute avoidance mechanisms are beneficial because the number of disputes arising can be reduced. The power or influence to avoid or minimize the occurrence of disputes changes as projects progress. Clients and project sponsors have the best opportunity to avoid disputes and maximize value (CRCCI, 2009).

Many previous studies identified and analysed the dispute causes affecting construction projects (e.g., Chong & Zin, 2012; Cheung & Pang, 2014; Cakmak and Cakmak, 2014; Mitkus & Mitkus, 2014; Lee et al., 2016; and Awwad et al., 2016). Table 1 shows the causes of disputes identified in some previous studies.

Table 1: Causes of Disputes Identified in Previous Studies

•	References	•	Dispute Causes
•	Chong and Zin (2012)		Conditions of contracts and misunderstanding of construction contracts
•	Mitkus and Mitkus (2014)		Poor management, inadequate design, unrealistic tendering, unrealistic client expectations and inadequate contract drafting
•	Cakmak and Cakmak (2014)		Project uncertainty, Contractual problems, Opportunistic behaviour, Contractors’ financial position and Cost of conflict and Culture
•	Lee et al. (2016)		Payment issues, changes in conditions, time and delays, bidding errors and lack of communication
•	Awwad et al. (2016)		Administrative causes, contractual causes, and cultural causes

Dispute management practice should include dispute avoidance, mitigation, and resolution processes (Mitkus and Mitkus, 2014). As per Sayegh et al. (2020), the two most common ways to mitigate disputes are avoidance and resolution. However, a lack of comprehensive observation of dispute avoidance strategies related to the Sri Lankan construction industry creates a gap in the literature.

3. RESEARCH METHOD

A survey strategy was used to identify appropriate dispute avoidance strategies in building construction projects in Sri Lanka. Since several parties of the construction project were affected due to disputes, a quantitative survey strategy was used with a large sample of professionals in the Sri Lankan construction industry.

The study population is the professionals in the construction industry in Sri Lanka. The sample was selected based on the convenient sampling method due to the time restrictions for the study and the unavailability of a published list of professionals involved in the Sri Lankan construction industry. Accordingly, 30 Quantity Surveyors, 10 Project Managers and 30 Site Engineers were selected for the sample of 70 professionals.

Questionnaires were prepared with the guidance of a literature review and findings of preliminary interviews to investigate dispute avoidance strategies in the construction industry. The Relative Importance Index (RII) statistical method and percentage calculations were used to analyse quantitative data.

4. DATA ANALYSIS AND FINDINGS

Out of 70 questionnaires, only 59 were returned, representing a response rate of 84%, considered an acceptable response level as it exceeds 80%. The experience distribution of the respondents to the questionnaire survey is shown in Figure 1. According to the respondents, most (55) have been involved in dispute management activities in the construction industry. Hence, these respondents give the research findings high accuracy and reliability.

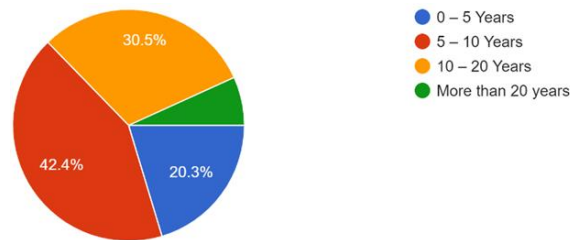


Figure Error! No text of specified style in document.-2: Years of working experience

Table 2 shows how the respondents identified the impact of some effects due to disputes on construction projects in Sri Lanka.

Table 2: Impact of the Effects of Disputes on the Construction Projects

#	Effects on the Construction Projects	View of the majority of respondents	% of the responses	RII Value	Rank
1	Time Overrun and Delays	Highly affect	41%	0.817	1
2	Cost Overruns	Highly affect	37%	0.786	2
3	Damages Reputation of all Parties	Affect	32%	0.719	3
4	Damages Goodwill & Relationship between all Parties	Moderately affect	34%	0.715	4
5	Suspension of the project	Affect	36%	0.664	5
6	Termination of Contracts by all Parties	Affect	31%	0.647	6

As per Table 2, time overrun, project delays, and cost overruns have been rated as the most impacted variables, with 0.817 and 0.786 RII values emphasising disputes are wasting both the cost and the time.

Table 3 gives reasons for dispute occurrence in construction projects in Sri Lanka and the extent of their effect on dispute occurrence with the avoidance ability.

Table 3: Causes of Disputes and Their Impact on Dispute Occurrence and Avoidance in Construction Projects in Sri Lanka

#	Causes of disputes	Impact on dispute occurrence		Ability to avoid	
		RII Value	Rank	RII Value	Rank
1	Payment issues	0.847	1	0.698	3
2	Variations/change orders/claims	0.841	2	0.685	8
3	Design issues and delays	0.827	3	0.692	7
4	Ambiguities in contract documents	0.803	4	0.712	1
5	Discrepancies and misinterpretations in specifications	0.800	5	0.698	3
6	Low-quality/ defective works by the contractor	0.800	5	0.685	8
7	Unclear scope definition	0.783	7	0.695	5
8	External Causes (e.g., Variations due to external events/codes/ regulations, Unforeseen ground conditions/Exceptional inclement weather, public interruptions/ municipality approvals, Environmental issues, Site limitations / differing conditions	0.783	7	0.651	17
9	Differences in the evaluation of changes	0.766	9	0.681	10
10	Unrealistic/ non-practical obligations	0.746	10	0.671	15
11	Unbalanced risk allocation	0.722	11	0.675	14
12	Inadequate site investigations	0.722	11	0.695	5
13	Incomplete or substandard information	0.722	11	0.661	16
14	Delayed site possessions/restricted access	0.715	14	0.705	2
15	Different interpretations of escalation/ de-escalation	0.712	15	0.678	13
16	Differences in construction techniques	0.681	16	0.681	10
17	Different material testing methods	0.644	17	0.681	10

Seventeen major dispute areas have been identified, and respondents are ranked them. Disputes due to payment issues ranked 1 with the highest RII value, 0.847. Disputes due to variations/change orders/claims ranked second with 0.841 RII value, and design issues and delays ranked third with 0.847 RII value.

Moreover, the respondents were asked about the extent of avoiding the above causes of disputes and ranked the ability to avoid them, as shown in Table 3. Ambiguities in contract documents, delayed site possessions/restricted access, payment issues, discrepancies and misinterpretations in specifications, unclear scope definition and inadequate site investigations are the top six causes of disputes that can be avoided.

Respondents are asked to rate eighteen dispute avoidance strategies according to their importance in avoiding disputes arising in construction projects. Table 4 shows the identified dispute avoidance strategies and how those strategies can avoid disputes in the Sri Lankan construction industry.

Table 4: Impact of Dispute Avoidance Strategies in Avoiding Disputes in Construction Projects in Sri Lanka

#	Dispute Avoidance strategies	View of the majority of respondents	% of responses	RII Value	Rank
1	Use of effective Communication protocol and coordination	Can highly avoid	39%	0.776	1
2	Establishing and adhering to proper payment practices	Can highly avoid	42%	0.769	2
3	Keeping and Maintaining records (timely and accurately)	Can avoid	36%	0.759	3

#	Dispute Avoidance strategies	View of the majority of respondents	% of responses	RII Value	Rank
4	Adherence to ethical and professional practices	Can highly avoid	41%	0.759	3
5	Practice corrective and preventive actions	Can avoid	39%	0.753	5
6	Accurately interpret the contract documents, including contract conditions, specifications, and drawings	Can highly avoid	36%	0.749	6
7	Identification, analysis and management of potential issues and problems	Can highly avoid	36%	0.749	6
8	Use of Standard forms of contract	Can avoid	34%	0.749	6
9	Building teamwork	Can avoid	32%	0.746	9
10	Good relationship management	Can highly avoid	36%	0.746	9
11	Regularly assessing project progress, costs, and performance	Can avoid	34%	0.742	11
12	Properly handle grievances and complaints	Can avoid	34%	0.742	11
13	Use techniques like Building Information Modelling (BIM)	Can avoid	32%	0.736	13
14	Define the scope of work very clearly	Can highly avoid	32%	0.732	14
15	Establish better Project team relationships	Can avoid	39%	0.725	15
16	Selection of well qualified Project team	Can avoid	44%	0.722	16
17	A proper and full understanding of Clients' needs and objectives	Can avoid	34%	0.708	17
18	Allocating fair Contract risk	Can avoid	32%	0.695	18

The respondents identified communication protocol and coordination as essential strategies to avoid disputes by ranking first with a 0.776 RII value and secondly, establishing and adhering to proper payment practices rated with 0.769 RII value since Sri Lankan construction projects face many issues due to payments. Keeping and maintaining records (timely and accurate) is the third highest-ranked strategy with a 0.759 RII value.

5. CONCLUSION AND RECOMMENDATION

This study aimed to guide construction industry participants with strategies to avoid disputes in Sri Lankan construction projects. A quantitative research approach-based survey strategy was followed in data collection.

As per findings, the most severe effects of disputes in building construction projects are time, delays, and cost overruns. The fundamental seventeen (17) significant causes of disputes identified causing disputes rigorously possessing RII values of more than 0.6. As per respondents, ambiguity in contract documents, delayed site possessions/restricted access, payment issues, discrepancies and misinterpretations in specifications, and unclear scope definitions are easily avoided. Interestingly, these factors are related to both the client and consultant.

Dispute avoidance possibility of eighteen (18) dispute avoidance strategies in construction projects in Sri Lanka was identified. The top five impacted dispute strategies are effective communication protocol and coordination, establishing and adhering to proper payment practices, adhering to ethical and professional practices, and accurately interpreting contract documents, including contract conditions, specifications, and drawings.

Based on the study's findings, construction industry participants can be guided as follows.

- It can be strongly recommended that dispute avoidance is more important than dispute resolution.

- The top 3 advantages of dispute avoidance are minimising (1) time overruns and delays, (2) cost overruns, and (3) damages to the reputation of all parties.
- Construction industry participants must emphasise minimising the following dispute causes having the high ability to avoid: (1) ambiguities in contract documents, (2) delayed site possessions/restricted access, (3) payment issues, (4) discrepancies and misinterpretations in specifications, (5) unclear scope definition, and (6) inadequate site investigations to avoid disputes.
- The top 10 dispute avoidance strategies to be followed by Sri Lankan construction industry participants are;
 1. Use of effective Communication protocol and coordination
 2. Establishing and adhering to proper payment practices
 3. Keeping and Maintaining records (timely and accurately)
 4. Adherence to ethical and professional practices
 5. Practice corrective and preventive actions
 6. Accurately interpret the contract documents, including contract conditions, specifications, and drawings.
 7. Identification, analysis and management of potential issues and problems
 8. Use of Standard forms of contract
 9. Building teamwork
 10. Good relationship management

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EVALUATION OF THE APPROPRIATENESS OF DELAY ANALYSIS TECHNIQUES FOR THE SRI LANKAN CONSTRUCTION INDUSTRY

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EVALUATION OF THE APPROPRIATENESS OF DELAY ANALYSIS TECHNIQUES FOR THE SRI LANKAN CONSTRUCTION INDUSTRY

ABSTRACT

Delay analysis techniques are used to conduct the delay analysis process and it is vital to select the appropriate technique depending on their characteristics. The study focused on evaluating the appropriateness of Delay analysis techniques used in Sri Lanka based on their key characteristics. The mixed research approach was adopted. Expert interviews and questionnaire surveys were used as the data collection methods. The findings of the interviews were analyzed through content analysis with the use of NVivo (version 11) software of QSR. Questionnaires were analyzed by using RII, MR, and CSS. Findings reveal that contemporary records are the most significant characteristic among the key characteristics identified when selecting a delay analysis technique for a particular construction project. This empirical study further recommended selecting suitable delay analysis techniques for a project based on its key characteristics.

Keywords: Delay Analysis; Delay Analysis Techniques; Key Characteristics

1 INTRODUCTION

According to Kabirifar and Ghafourian (2014), time is a major index of productivity in the construction industry. Even though completing projects within the scheduled time is an important indicator of efficiency, it is a well-known fact that the construction process has to suffer from several unpredictable circumstances and variables resulting from several sources such as resource availability, environmental conditions, and performance of the parties to the contract (Assaf & Al-Hejji, 2006). Time consumption after the project duration agreed upon by the employer and the contractor is defined as a delay to a project (Elhousseiny, Nosair, & Ezeldin, 2020). Gebrehiwet and Luo (2017) identified several impacts of delays as cost overrun, termination of the contract, arbitration, and litigation. According to Shahsavand et al. (2018), the employer, the contractor, acts of God, or a third party are causes for delays in construction projects. Further, a project has to be completed within the allocated budget and time while meeting the projected requirements to consider it a successful project (Ekanayake & Perera, 2016). In addition to that, Durdyev et al. (2017) stated that along with cost and quality, time is the most significant aspect of the project's success. However, at present, the matter of time overrun is considered one of the most challenging issues for the construction industry (Elhousseiny et al., 2020). Within the context of Sri Lanka, Kesavan et al. (2015) stated that a considerable number of construction projects do not accomplish their scheduled contract time. Paray and Kumar (2020) state delay analysis as a process of investigating causes for time overruns and responsible parties for the delays. Therefore, there should be a systematic delay analysis process to mitigate the impact of delays in a construction project. Gunarathne (2012) identified that ad hoc methods are used for evaluations of claims for time extensions by most of the professionals who involve in construction delay analyzing processes. Hence, it is vital to select an appropriate delay analysis technique to mitigate the impact of delays. There is a need for more studies to evaluate the appropriateness of delay analysis techniques for the Sri Lankan construction industry. Most previous studies target specific project categories such as water projects and road construction projects. Nevertheless, this research recommended an evaluation of the appropriateness of delay analysis techniques based on key characteristics of delay analysis techniques.

2. LITERATURE REVIEW

2.1. DELAYS IN CONSTRUCTION INDUSTRY

According to Elhousseiny et al. (2020), delays in construction projects are contemplated as one of the most crucial issues that are being suffered by the current construction industry. Furthermore, Ahmed et al. (2003) stated that construction delays are generally recognized as the most complex, risky, and costly matter encountered in construction projects. Assaf and Al-Hejji (2006) defined construction delay as

the time overrun to the project and it can be either beyond the completion date stated in the contract or beyond the date that is agreed by the parties upon completion of the project. Different researchers and authors have divided delays in the construction industry into several categories (Fakunle & Fashina, 2020). However, Keane and Caletka (2009) stated that most of those classifications are based on similar fundamental phrases and they are likened to one another. Paray and Kumar (2020) have divided delays into two main categories as Critical Delays and Non-Critical Delays based on their impact on the project program. In addition to that, construction delays can also be classified based on the party that is liable for those delays, i.e., Non-Excusable Delays, Excusable Delays, and Concurrent Delays. Moreover, Excusable Delays can be further categorized as Non-Compensable Delays and Compensable Delays (Menesi, 2007).

Subsequently, Kesavan et al. (2015) mentioned that large numbers of construction projects in Sri Lanka are unable to complete within their original completion date stated in the contract. Furthermore, according to Ekanayake and Perera (2016), 80% of road construction projects in Sri Lanka have encountered construction delays. In addition to that, Perera and Halwatura (2012) disclosed that there are delays in the construction of water supply projects in Sri Lanka and conducted a study to identify the delay factors that affect the delay of medium-scale water supply projects in Sri Lanka.

2.2 DELAY ANALYSIS TECHNIQUES

According to Braimah (2013), Disputes related to delay claims are one most complicated types of disputes to resolve and a main source of conflict in the construction industry. It is essential to have a comprehensive analysis to explore what has caused the delay of the project. Many Delay Analysis Techniques are being implemented by employers and contractors to analyze delays. According to Hegazy and Zhang (2005) many researchers have introduced several delay analysis techniques and different authors practice alternative names for the same methods. Some of them can be listed as follows.

1. As-planned vs as-built technique
2. Impacted as planned technique
3. Collapsed as built
4. Time impact analysis
5. Window analysis

2.2.1 AS-PLANNED VS AS-BUILT TECHNIQUE

The main concept behind this method is to compare two distinct schedules called as-planned schedules and as-built schedules (Meena & Babu, 2015). According to Mohammed and Jafar (2011), the time difference between the as-planned schedule and the as-built schedule is observed in this method. That time difference is the amount of time that is applied to a request for compensation by the claimant. All delay events that occurred in the project are represented on the as-built schedule under this method (Braimah, 2013).

2.2.2 IMPACTED AS PLANNED TECHNIQUE

Impacted-as-planned techniques compute the impact of the delays on the as-planned schedule of the contractor (Braimah, 2013). Therefore, only an as-planned schedule or baseline schedule is used for the delay analysis process under this method (Mohammed & Jafar, 2011; Ndekugri, Braimah, & Gameson, 2008). Different delays caused by either employer or contractor are formulated as activities and inserted into the as-planned schedule in sequential order. It indicates the impact of each delay at a particular time and shows how the project is being delayed (Braimah, 2013).

2.2.3 COLLAPSED AS BUILT TECHNIQUE

The collapsed as-built method can be identified as a modification to the as-planned vs as-built method (Ekanayake & Perera, 2016). Collapsed as built technique subtracts the delay events which are attributable to the owner from the as-built schedule to ascertain what would have occurred but for those events (Mohammed & Jafar, 2011). Then the as-built schedule is recalculated by allowing the remaining activities to collapse. The time difference between the subsequent completion date and the actual completion date of the project is considered as the delay which is attributable to the owner (Hafez, 2013).

2.2.4 TIME IMPACT ANALYSIS

The time impact analysis method is a variant of the window analysis method with the difference being that time impact analysis considers only a particular day, and not a period containing several delays (Ndekugri et al., 2008). It compares the schedule right before a delay arises with the adjusted schedule just after that delay (Hafez, 2013). The amount of delay caused by a particular delay event can be determined by the difference between the new completion date and the date prior to the delay event (Meena & Babu, 2015).

2.2.5 WINDOW ANALYSIS

The window analysis method is also referred to as the snapshot method and the contemporaneous period analysis (Meena & Babu, 2015). Hafez (2013) stated that the window analysis method is based on the as-built schedule, the as-planned schedule which is used as the baseline schedule, and any other revised schedules that are used during the construction process. According to Menesi (2007), this method divides the construction period into separate time slots called 'windows' based on major deviations in planning or major project milestones. Hence, the window analysis technique can split a complicated work program into more manageable ones (Braumah, 2013).

2.3. SELECTING THE MOST APPROPRIATE DELAY ANALYSIS TECHNIQUE

Ekanayake and Perera (2016) mentioned that there should be comprehensive knowledge regarding available delay analysis techniques before choosing the most appropriate delay analysis techniques for construction projects. According to Menesi (2007), the selection of the most suitable delay analysis technique depends on numerous factors such as the value of the dispute, available time, available records, and cost allocated for the delay analysis. Nevertheless, Enshassi and Jubeh (2008); Orban, Nassar, and Hosny (2018) identified more characteristics that have an impact on selecting a delay analysis technique. Those are records availability, availability of the updated program, time of delay, the reason for the delay analysis, type of contract, cost for the analysis, size of the project, duration of the project, skills of the analyst, and the number of delaying events.

2.4. DELAY ANALYSIS TECHNIQUES IN THE SRI LANKAN CONSTRUCTION INDUSTRY

Limited studies have been carried out related to suitable delay analysis techniques for the Sri Lankan construction industry. Ekanayake and Perera (2016) identified nine criteria that need to be considered when selecting a delay analysis technique for road construction projects in Sri Lanka. Those are the time taken for the analysis, cost of analysis, workability of the technique, reliability of the technique, accuracy of the technique, acceptability to relevant parties, acceptability to courts and tribunals, complexity of the analysis, and input of experts. According to Sudeha et al. (2013), record availability, the other party to the claim, applicable legislation, the form of contract, skills of an analyst, size of the project, complexity of the project, time availability for delay analysis, cost of technique, time of the delay, number of delay events and nature of delays, are most critical factors that have an impact on choosing the most suitable delay analysis technique in the Sri Lankan construction industry. There can be several delay events in a construction project and Sudeha et al. (2013) argued that all delay events cannot be achieved by a single delay analysis technique. Therefore, it is important to recognize

appropriate delay analysis techniques for each delay event in a construction project to complete the project successfully. This study analyses the suitability of different delay analysis techniques based on their key characteristics rather than selecting one delay analysis technique for a project.

3. RESEARCH METHODOLOGY

This research is about identifying the appropriateness of delay analysis techniques used in the Sri Lankan construction industry, based on their key characteristics. The selected research approach was a mixed approach as the study required both quantitative and qualitative data. Data collection was done in two phases, data was collected through expert interviews in the 1st phase, and a questionnaire survey was conducted to collect data in the 2nd phase. Eight experts who have more than 20 years of experience in the construction industry were interviewed and collected data was then used for the questionnaire survey. Accordingly, 65 questionnaires were distributed among project managers, engineers, and quantity surveyors and 43 questionnaires were received. “Professionals in the construction industry in Sri Lanka” is the population determined for this research since the research is limited to the Sri Lankan construction industry. The sample set for this study is “the professionals who have experience of more than five years in construction delay analysis in the Sri Lankan construction industry”. The random sampling technique is selected for this study since it requires the common idea of the professionals in the construction industry. The findings of the interviews were analyzed by using content analysis with the use of NVivo (version 11) software of QSR. Questionnaires were analyzed by using RII (Relative Importance Index), MR (Mean Weighted Rating), and CSS (Criterion Suitability Score).

4. RESEARCH FINDINGS

4.1. DELAY ANALYSIS TECHNIQUES PRACTICING IN SRI LANKA

Most of the respondents mentioned the use of the as-planned vs as-built technique as a delay analysis technique in Sri Lanka. According to R3, R5, and R6, the main reasons behind the use of as-planned vs as-built techniques are simplicity and the less time-consumption of technique. R2 supported the same emphasizing the easiness of technique with the use of project planning software such as MS Office and Primavera during the delay analysis process. Moreover, R4 said that the *“as-planned vs as-built technique is mostly practiced in the industry because of being well aware of the technique among most of the professionals in the industry”*. Apart from that, collapsed as-built is also often practiced in Sri Lanka. R8 introduced collapsed as-built technique as a subtractive system since it subtracts delays from the as-built schedule. Moreover, R5 mentioned that this technique is also known as the ‘but for’ method or ‘as-built but for’ method in the industry. Furthermore, R1 stated that *“First all the delays applicable to contractor and employer are inserted to the as-built schedule and set contractor’s delays as zero so that delays applicable to the employer can be obtained. Similarly, delays which apply to the contractor can be gained by setting the employer’s delays as zero”*.

R6 declared that in window analysis, the construction program is divided into equal time slots called ‘windows’, and delays are calculated based on windows. R8 discussed the size of a window and stated *“Generally, the size of a window is 15 to 25 days, and it depends on the duration of the project and the probability of occurring delays. Also, window size should be equal except the last window because, with the duration of the project, it is hard to set the last window to equal with other windows”*. R8 further stated that window analysis requires expert professionals to conduct the delay analysis process and a considerable amount of time and cost have to be spent for window analysis. However, window analysis provides a more reliable outcome.

Impacted as planned technique and time impact analysis is another type of delay analysis technique practiced in Sri Lanka. Nevertheless, R1 and R5 stated that even though it is used in Sri Lanka, they are practiced very rarely. R5 stated that *“Impacted as planned method and time impact analysis requires accurate and updated construction program to the delay date to identify the exact position of delay*

event in the construction program. But unfortunately, most of the contractors are not maintaining the updated program. So those two techniques are very rarely used in Sri Lanka". According to R6 impacted as-planned method is a less time-consuming and inexpensive method. However, most professionals are reluctant to use it because of its low reliability of output. Moreover, R4 stated that time impact analysis can analyze delays one by one separately and it denotes more accurate results even though it is a costlier analysis method.

4.2. KEY CHARACTERISTICS THAT SHOULD BE CONSIDERED WHEN SELECTING A DELAY ANALYSIS TECHNIQUE

Table 1 shows RII values for key characteristics to be considered when selecting a delay analysis technique based on respondents' perspectives.

Table 8: RII for characteristics when selecting a delay analysis technique

Key Characteristics	Relative Importance Index (RII)	Rank
Contemporary records	0.800	1
Cost of the analysis	0.753	2
Nature of the delay events	0.749	3
Time is taken for the analysis	0.707	4
Reliability of the outcome	0.698	5
The skill of the analyst	0.693	6
Number of delay events	0.670	7
The complexity of the analysis	0.665	8
Project information	0.647	9

Respondents ranked contemporary records as the most important characteristic when selecting a delay analysis technique with a 0.8 RII value. Contemporary records are mandatory to conduct a delay analysis process. These records include various correspondences, progress reports, inspection reports, updated schedules, photographic evidence, and handover reports. If contemporary records are unavailable, analysts have to proceed with reasonable assumptions, and it may lead to deriving unreliable outcomes from the analysis. The cost of the analysis has been ranked in the second position by the respondents. Delay analysis can be an extremely costly process, especially when using techniques such as window analysis and time impact analysis. This makes it mandatory to consider the value of the claims and the cost involved in processing those claims to ensure the selection of a cost-effective technique. Respondents have ranked the nature of the delay events in the third position with a 0.749 RII value. Generally, delay events can be categorized as employer-related delays, contractor-related delays, and neutral delays. Thus, it is necessary to identify the risk allocation between parties by referring to the contract when selecting a delay analysis technique. The respondents have ranked the complexity of the analysis in the eighth position. Complex delay analysis techniques require more experts, time, and cost. However, when the delay analysis gets complex it derives the most accurate results from the analysis.

4.3. MAPPING THE APPROPRIATENESS OF DELAY ANALYSIS TECHNIQUES BASED ON THEIR KEY CHARACTERISTICS

Table 2 illustrates the most suitable delay analysis technique for a given characteristic based on the highest CSS values obtained by all the techniques. Accordingly, if limited time is available and no experienced experts for the delay analysis, as-planned vs as-built technique can be applied as it has

taken the highest CSS values for the time taken for analysis (2.465) and skill of the analyst (2.401). Further, the parties expect to spend less cost for the analysis they can proceed with the collapsed as-built method as it has taken the highest CSS value for respective characteristics. Moreover, it can be used in situations where detailed contemporary records and project information are not available. Nevertheless, the impacted as-planned technique has obtained the highest CSS value (2.244) for the complexity of the analysis which indicates that it is suitable for when a simple delay analysis process is needed. Furthermore, window analysis is most suitable to apply when there are concurrent delays as it can analyze all types of delays. Also, it can be applied when there are a greater number of delays to analyze since it has taken the highest CSS for the number of delay events. Moreover, window analysis is the most reliable technique which has the highest CSS value (3.200) among all the methods, so it is suitable when the accuracy of delay analysis becomes a major consideration for the parties.

Table 9: Criterion Suitability of Different Delay Analysis Techniques

Key Characteristics	CSS					Most suitable DAT
	As planned vs as built	Collapse d as built	Impacted as planned	Time impact analysis	Window analysis	
Time taken for the analysis	2.465	2.179	1.506	1.147	1.457	As planned vs as built
The skill of the analyst	2.401	0.937	1.746	1.664	1.261	As planned vs as built
Reliability of the outcome	0.624	2.435	0.781	3.051	3.200	Window analysis
Project information	1.972	2.120	1.171	2.091	1.972	Collapsed as built
Number of delay events	1.636	2.212	2.092	2.243	2.737	Window analysis
Nature of the delay events	1.170	1.192	2.120	1.971	2.665	Window analysis
Cost of the analysis	2.179	2.465	1.800	1.215	1.609	Collapsed as built
Contemporary records	0.857	2.700	1.717	1.557	2.273	Collapsed as built
The complexity of the analysis	1.941	0.486	2.244	1.382	1.215	Impacted as planned

Accordingly, As planned vs as-built technique is the most suitable delay analysis technique in terms of key characteristics; time-taken for the analysis, and skills of the analyst. In addition to that, this technique can be used when limited cost and project information are available since it requires a low degree of project information for the analysis. If the parties highly consider the accuracy of the delay analysis outcome, window analysis is the most appropriate delay analysis technique. Moreover, window analysis is appropriate in terms of characteristics such as the number of delays and the nature of the delay events since window analysis can analyze any type of delay with a high number of occurrences. Further, this technique can be used when contemporary records are not available since it requires a low degree of contemporary records. Time impact analysis also indicates slightly the same key characteristics in terms of appropriateness with the window analysis as per the outcome of the data analysis. However, respondents have recommended window analysis as the most appropriate delay analysis over time impact analysis in terms of those key characteristics.

5. CONCLUSIONS

Post-disaster Delay analysis is a process of investigating root causes for time overruns and responsible parties for the delays. The techniques which are used to analyze delays are identified as delay analysis techniques. There are various types of delay analysis techniques. Among them, as planned vs as built, collapsed as built, impacted as planned, window analysis, and time impact analysis are the most common delay analysis techniques used in Sri Lanka. The selection of a delay analysis technique for a project depends on its key characteristics. Accordingly, nine key characteristics that have an impact on the selection of a delay analysis technique were identified. Those can be listed as the time taken for the analysis, skill of the analyst, reliability of the outcome, project information, number of delay events, nature of the delay events, cost of the analysis, contemporary records, and the complexity of the analysis. Among those techniques contemporary records, the cost of the analysis, and the nature of the delay events are the most important characteristics that have an impact on the selection of a delay analysis technique for a project. Accordingly, window analysis is suitable in terms of reliability, number of delay events, and nature of the delay. As planned vs as-built technique is more appropriate where there is less time and fewer analysts are available. The collapsed as-built technique is suitable when there are less project information and contemporary records. Impacted as planned technique can be used when simple delay analysis is required.

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**ANALYZING ADMINISTRATIVE DELAYS IMPACTING
INFRASTRUCTURE PROJECTS: A COMPREHENSIVE SYSTEMATIC
REVIEW**

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ANALYZING ADMINISTRATIVE DELAYS IMPACTING INFRASTRUCTURE PROJECTS: A COMPREHENSIVE SYSTEMATIC REVIEW

ABSTRACT

Infrastructure development stands as a pivotal economic pillar for nations. However, administrative functions frequently underlie delays in project implementation. To address this, a systematic literature review, utilizing the PRISMA method, delved into the causal factors of administrative delays. From a pool of 28 studies, critical insights were gleaned, shedding light on the intricacies of administrative inefficiencies. These identified issues, which can emanate from project organizations and external entities alike, were examined to offer solutions for curtailing time and cost overruns. The study underscores the potential to streamline administrative processes across project organizations and involved external entities, presenting a promising avenue to mitigate the adverse impacts of delays in infrastructure projects.

Key words: *Administrative delays; Causes of delays; Delays; Infrastructure projects; PRISMA*

1. INTRODUCTION

Infrastructure emerges as a pivotal element within a society, furnishing vital goods and services for daily life while intricately connecting to the nation's economic framework. (Toscano et al., 2022). Gunawansa (2012), as cited in McDermot et al. (2020), elucidates the impact of infrastructure facilities on citizens' well-being, exemplifying that extending every 1km of road in India could alleviate the poverty of 10 individuals. Similarly, Patel (2014) stated that infrastructure is a *sine qua non* for uplifting the well-being of the people whereas Ghosh (2017) indicated it as a public good. The categorization of infrastructure primarily encompasses economic (physical) and social dimensions (Butkovic et al., 2019; Grum & Grum, 2020). Physical infrastructure encompasses elements like roads, highways, telecommunications, and bridges (Grum & Grum, 2020), while social infrastructure encompasses domains like education, healthcare, tourism, and culture (Latham & Layton, 2019). Patrucco et al. (2022) stated that US\$ 4550 billion will be allocated for new infrastructure and total of \$1.2 trillion for rebuilding the infrastructure within next 5 years in United States. Hence, investing on infrastructure is a key function in any country irrespective to the socio-economic status of a country.

Study by Ruize-Nunez & Wei (2015) estimated the global infrastructure investment is about US\$ 53 trillion over 2010-2030 and US\$ 2.7 trillion of annual average. In addition, author mentioned that the annual investment requirement would be risen up from 2.5% to 3.5% of world GDP. Hence, bridging the above gap required high capital which could be obtained through government budgets and bonds, the Official Development Assistance (ODA) or private capital investments (Babatunde et al, 2017). Even though, larger investments are disbursed in a country, Flyvbjerg et al. (2013) emphasized that larger share of initial budget will be exceeding the initial cost of the projects. Hence, project delays have to be studied the causative factors affecting to infrastructure project delays. Multiple studies were undertaken to ascertain the factors influencing infrastructure project delays across various timeframes (Rahman et al., 2006; Thuyet et al., 2007; Panova & Hilletoft, 2018; Alsulamy, 2022). Often, the determinants of infrastructure delays are focused on intricately technical concerns. Rahman et al. (2006) emphasized that project delays often arise from variations, planning complexities, inadequate information, and insufficient funds, leading to site possession delays. However, Cantarelli et al. (2013) inferred that certain factors defy technical explanations. Hence, comprehending diverse factors and their categories influencing infrastructure delays assumes significance in research.

In their study, Doloi et al. (2012) examined 45 attributes associated with project delays, categorizing them into six primary factors: project-related, site-related, process-related, human-related, authority-related, and technical-related. Alaghbari et al. (2007) delineated the causes of construction project

delays as either internal or external. Internally, delays stem from stakeholders such as owners, contractors, designers, and consultants; externally, delays are triggered by external entities like government, suppliers, and weather. Some researchers have delved into internal factors more extensively. Mahamid et al. (2012) identified causes of road infrastructure project delays within distinct groups, encompassing owners, materials, labor, design, contracts, and consultants. The external category included political situations, exchange rate fluctuations, banking policy shifts, weather, monopoly, and natural disasters. In contrast, Prasad et al. (2019) underscored external delays arising from permissions or stakeholder approvals. Both factors intertwine with decision-making capacity based on accessible information. Moreover, Hossain et al. (2022) and Alijohani et al. (2017) emphasized the significance of timely information for efficient decision-making by clients and other external parties. Henceforth, Martens and Weelden (2014), Owolabi et al. (2014) remarked lack of information is coincided with the slow decision making in infrastructure projects. Similarly, Prasad et al. (2019) emphasized delay in decision making by owner is determined as one of the sub factors of delays under owner category. In order to take a quality decision, sound administrative procedures are emphasized by Ponce (2005). Further, Davidsson & Gustafsson, 2011 revealed that administrative processes or management processes are required to generate information and decisions in a process. More to then, Zidane and Andersen (2017) revealed that slow decision-making process and issues in internal administrative processes, are key obstacles for infrastructure project progress in Norway. Similarly, Windapo et al. (2014) investigated those administrative delays are 4th highly affecting factor in African construction industry. Further, highway projects are getting delay due to administrative delays in decision making in Vietnam. In both developing and developed nations, delays in administrative processes can be observed, transcending their developmental status. Efficient management of administrative processes is imperative for effective decision-making and reducing delays in infrastructure projects. Identifying factors that contribute to administrative delays and their subsequent impact on project timelines is vital for devising mitigation strategies. Consequently, a systematic literature review (SLR) is conducted to explore factors influencing administrative delays in infrastructure projects. Lin et al. (2021) propose a monitoring framework for infrastructure projects at each stage, while Hussain et al. (2018) note that delay causes vary by country, region, geography, and administrative disparities. Thus, prior to investigating administrative delays in the Sri Lankan context, it is crucial to examine previously studied factors. Therefore, the importance of conducting a SLR to establish connections among various causes of administrative delays in infrastructure projects is underscored. The aim of the SLR is to investigate the causes for the administrative delays in infrastructure projects. The objectives of the studies are to identify the causes affecting to the administrative delays and categorize the causes for administrative delays in infrastructure projects. This paper starts with an introduction to importance of infrastructure, directing to the research objectives. Next, a literature review on administrative processes in infrastructure projects will be discussed. Subsequently, the research method, results and discussion will be presented.

2. LITERATURE REVIEW

2.1. ADMINISTRATIVE PROCESSES IN INFRASTRUCTURE PROJECTS.

Simon (2000) defined administration as the art of getting things done and the theory of administration is linked with processes of decision as well as with the process of activities. Hence, the formalized way of the things getting done can be defined as an administrative process. Further, author concluded that goal of the proper administrated system is to facilitate the decision making. Simon (2003) highlights the inclusion of fact-finding, design, analysis, reasoning, and negotiations with a substantial dose of intuition in the decision-making process. Kartz (2009) further delineated the three essential skills for effective administrative behavior: technical, human, and conceptual skills. Throughout the lifecycle of infrastructure projects, encompassing development, construction, and operation, a multitude of permits and approvals become requisite (Vilventhan and Kalidindi, 2012). Further, Lin et al. (2021) and Vilventhan and Kalidindi, (2012) mentioned that all of the infrastructure projects have undergone

several stages as project conceptualization, feasibility analysis, planning of the project, approval, awarding of contracts, construction/procurement, operation and maintenance. Furthermore, distinct levels of approvals and administrative procedures govern decision-making at each project stage. Vilventhan and Kalidindi (2012) investigate administrative delays as a significant cause for infrastructure project delays in India. Similarly, enhancing administrative processes, as proposed by Gharehbaghi et al. (2019), could potentially reduce construction time in infrastructure projects. Hence, the necessity of devising strategies to enhance effective decision-making at every infrastructure project stage underscores the significance of identifying and categorizing administrative causes and their interrelation with other factors.

3. RESEARCH METHODOLOGY

Ali et al. (2017) and Page et al. (2021) defined a systematic review (SR) is a logical way of extracting the knowledge in a particular topic area to disseminate among the research community, which has proceeded by a set of guidelines to increase its validity by repeatability of results by using the search strategy. In this study the SLR is conducted by using the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 guideline. The PRISMA statement substitutes the initial 2009 statement and includes new reporting guidance that includes with advances in methods to identify, select, appraise, and synthesize studies with 27-item checklist (Page et al., 2021).

As per the PRISMA checklist items the objectives are formulated and accordingly, the search strategy is formulated by using keywords and Boolean operators as presented in Table 1 and Figure 1.

Table 1: PRISMA checklist items of the study

Title, Abstract, keywords	Boolean operators	In all text
“Administrative delays”	AND	Infrastructure projects OR Infrastructure project
Causes OR Causes OR Factors OR “factors affecting to”	AND	Administrative delays
	OR	“Administrative delays in projects” OR “administrative delays in infrastructure projects”
“Administrative causes” OR “Causes for administrative delays” OR “lean concept”	AND	“Internal environment” OR “External Environment”

As given in Table 1, the search strategy key words “administrative delays”, “causes for administrative delays”, “Infrastructure projects”, “infrastructure project delays”, “construction project delays”, “factors for administrative delays”, “factors” “administrative factors” are used. Consequently, three more reliable search engines such as Google scholar databases such as, Scopus, Science Direct publishers such as Taylor and Francis, Emerald insight recommended by Alblooshi et al. (2020) are used to collect the publications. Next, the screening of the relevant articles is undergone with following PRISMA flow-diagram.

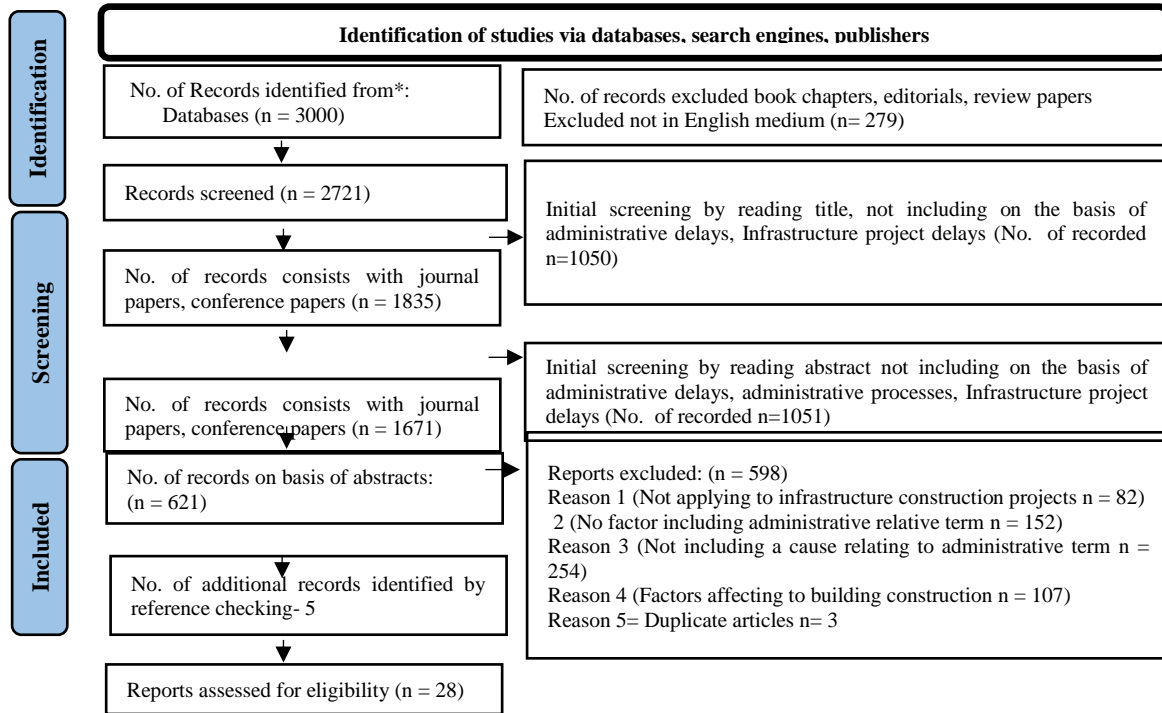


Figure 1: PRISMA flow diagram

Initially, the repository comprised with 3000 publications by accumulating the publications searched from 5 sources. and by using excluding criteria as not in English language 279 articles were removed. The subsequent screening was done by reading title, abstracts and filtrate with 1671 articles. Next, a thorough screening steps were carried out to select the most relevant studies. Thereafter, 4 rigorous excluding criterias were used such as not applying to infrastructure construction projects, no factors including administrative relative term, not including a cause relating to administrative term, factors affecting to building construction and duplicate articles were removed. The final repository consists with 28 articles and subjected to the content analysis.

4. RESULTS AND DISCUSSION

The administrative causes for delaying infrastructure projects and the sub causes for the identified cause was analysed by manual content analysis. Mittal et al. (2020) compares factors affecting to delays in infrastructure projects in developing countries and identified linkage among the factors in different countries. However, causes for administrative delays are not studied. Table 2 explains the administrative causes for delaying infrastructure projects in different countries.

Table 2: Causes affect to Administrative Delays in Infrastructure Projects

Causes for administrative delays	Country (s)	Source	Organizational environment	
			Internal	External
Delays in government consents and delays in approvals/ permits/Project approvals	4, 8, 9, 17	C, F, G, T, W		√
Executive bureaucracy in the client's organization	11	B	√	
Slowness of decision making	11	B	√	√
Complexity and delays in administrative procedures	2, 8	C, E, U	√	√
Regulations compliances related factors	4	M		√

Administrative delays in authorities	1, 5	N, Q		√
Bureaucracy in client's organization	4	H	√	
lack of human capital to design and monitor contracts and cope with administrative work	16	P	√	
Extensive administrative work involved in contract design and management, coupled with labor shortages	16	P	√	
Issues in governance and administrative processes	5	Q		√
Institutional resistance	6, 5	Q, R		√
Extending administrative process for approval	3	S, U, J	√	√
Administrative issues/delays	4	V, W	√	√
Schedule delay by administrative procedure	14	Y	√	
Issues of internal administrative procedures	7	D, Z	√	√
Bureaucracy within project organization		Z	√	
Issues in institutional and administrative system	11,13	B, X	√	√
Political discourses	5	Q		√
1-Brazil, 2- Egypt, 3-Hong Kong, 4-India, 5-Germany, 6-Iraq, 7-Jordan, 8-Libya 9-Nigeria, 10-Norway, 11-Oman, 12-Pakistan, 13-South Africa, 14-Taiwan, 15-UK, 16-US, 17-Vietnam				
A-Ahmed et al (2003), B- Alamri et al. (2017), C- Alfakhri et al. (2017), D- Al Hazim et al. (2017), E- Aziz et al. (2016), F- Babatunde et al. (2017), G- Battaglini et al. (2012), H- Doloi et al. (2012), I- Farooqui et al. (2008), J- Ghiasi et al. (2017), K- Greenwood et al. (2001), L- Kalkani and Malek (2016), M- Mittal et al. (2020), N- Neto et al. (2018), O- Pall et al. (2016), P-Patrucco et al. (2022), Q- Puka and Szulecki (2014), R- Rezouki and Hassan (2019), S- Singh et al (2016), T- Sy et al. (2014), U- Steinbach (2013), V- Viles et al. (2019), W- Vilventhan and Kalidindi (2012), X- Windapo et al. (2014), Y-Yang et al (2010), Z- Zidane and Andersen (2017)				

As shown in table 2, most of the countries identify the administrative factor as administrative and management factor affect to the infrastructure delays. Greenwood et al. (2001) conducted a study to investigate the causes for administrative delays of hospital construction projects in Libya and England. cause. Further, Farooqui et al. (2008) explored on administrative and management practices together in reporting cost overruns in infrastructure projects. Vilventhan and Kalidindi (2012) disclosed that more than 65% of 441 road projects were overdue with cost and time overruns owing to administrative delays in administrative processes and slow decision making of approval authorities. Out of the above countries, most of the studies were conducted in India relation to investigate on more roots for administrative dilemma in infrastructure projects especially in the road projects. In addition, administrative causes were screened as key delay causes for transmission projects (Pall et al., 2016). In various developing countries, such as India, Libya, Nigeria, and Vietnam, project delays stem from delays in government consents, permit issuance, and project approvals. Executive bureaucracy within client organizations and sluggish decision-making processes contribute to these administrative delays, as noted by Alamri et al. (2017). Sing et al. (2016) unveiled that government policy amendments require approvals from the Public Works Subcommittee of the legislative council, consuming up to a year. These external administrative challenges emanate from the project organization's broader environment. Simultaneously, internal administrative processes can also lead to time overruns in infrastructure projects. Ahmed et al. (2003) highlight that project delays can arise from both internal parties (owners, designers, contractors, and consultants) and external entities connected to the project, including the government. Given the involvement of multiple authorities across project planning, design, and execution, the aforementioned administrative challenges can be categorized as originating from the internal or external environment. In conclusion, the aforementioned administrative issues, whether internal or external, significantly impact project organizations during the planning, design, and execution stages.

According to the above table 2, most of the administrative causes for delaying infrastructure projects are grouped under both external and internal environments. Out of those causes, administrative and management factor, slowness of decision making, complexity and delays in administrative procedures, administrative delays, extending administrative process for approval, administrative issues/delays, institutional and administrative system and internal administrative procedures are causative for

administrative delays in both external organizations such as government institutes responsible for project approvals, environmental clearances and monitoring and licensing authorities such as local government institutes at project initiation up to execution stages. However, exploring the administrative causes of infrastructure project delays and categorizing them into internal and external environments will aid in identifying the fundamental causes behind each cause.

4.1 Causes and Sub Causes for Administrative delays in Infrastructure Projects

Given that certain administrative causes of infrastructure project delays span both internal and external environments, these causes can be subdivided into specific subcategories within the overarching cause. This notion finds support in Greenwood et al.'s (2001) study, which initially categorized causes into administrative, technical, financial, and unforeseen event factors. The study further revealed the amalgamation of administrative causes with technical issues, where protracted decision-making worsened frequent modifications. Thus, potential interconnections between identified causes may arise. The following map is developed to present the causes and sub-causes for administrative delays in infrastructure projects.

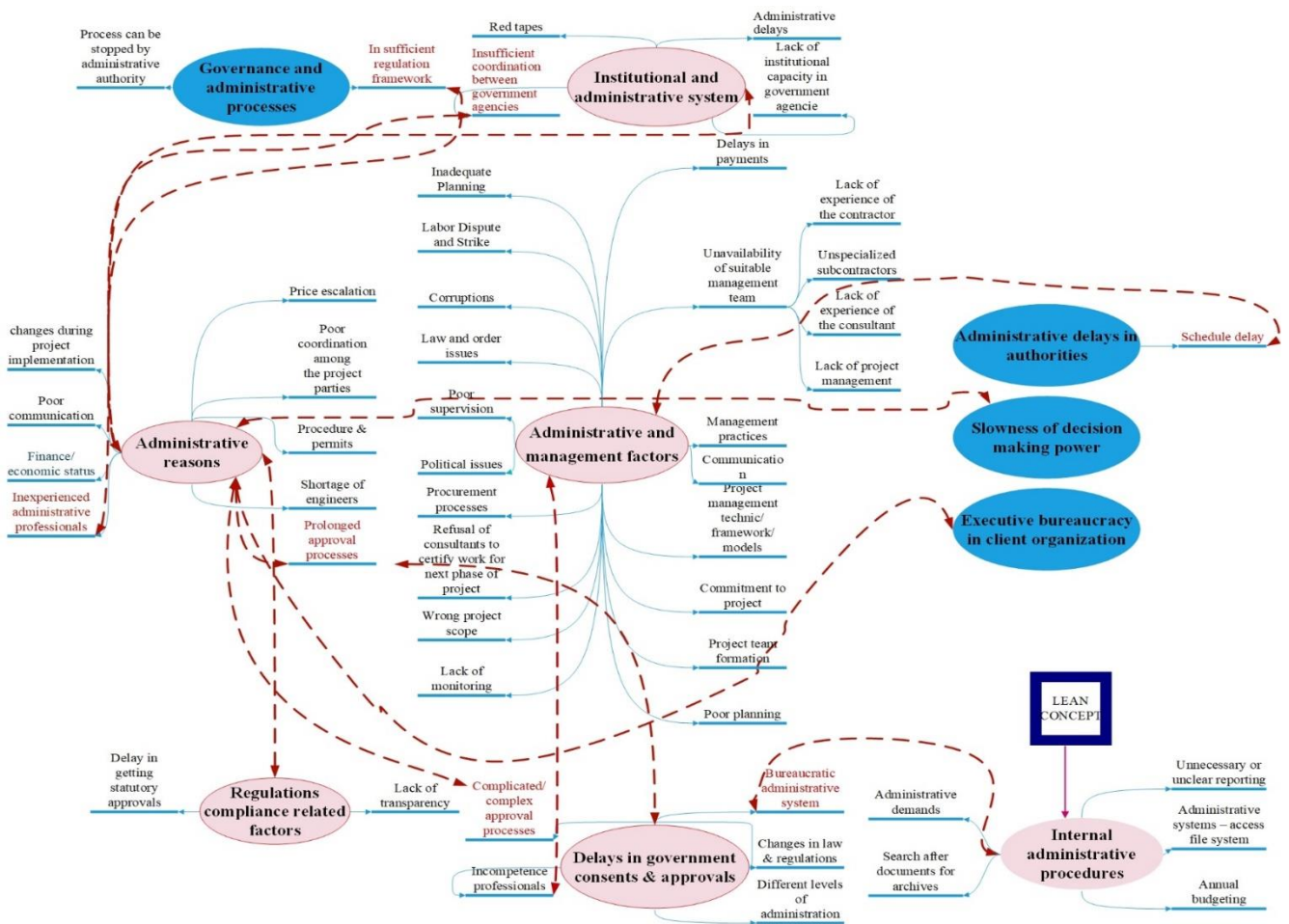


Figure 2: Causes for administrative delays in infrastructure projects

Figure 2 categorizes numerous causes into distinct levels, particularly emphasizing administrative and management-related factors, which are further divided into causes and sub-causes. Ahmed et al. (2003) expanded on these, outlining divisions such as labor dispute and strike, inadequate planning, inadequate scheduling, contract modifications, underestimation of productivity, staffing problems, lack of coordination on-site, scheduling mismanagement, transportation delays, suspensions, inadequate review, lack of high-technology, poor managerial skills, building permits approval process, and changes in laws and regulations within the context of US infrastructure projects. Conversely, the insufficiency of an appropriate management team is subdivided into availability of a suitable management team, unspecialized subcontractors, lack of project management, lack of contractor experience, and lack of consultant experience. These factors predominantly relate to the internal project organization environment. Windapo et al. (2014) associated corruption, law and order issues, and political factors with externally derived causes in administrative reasons leading to infrastructure project delays. Furthermore, the presence of incompetent professionals is linked to two primary causes: delays in government consents and approvals, and administrative and management factors. Moreover, inefficient regulation framework categorized under governance and administrative processes (Puka and Szulecki, 2014) and this factor also link with the in efficient coordination between government agencies under institutional and administrative systems explained by Windapo et al. (2014). By reviewing this relationship, it can be clearly emphasized that interconnection between government institutes have to be improved by adapting to necessary changes of regulations in order to successfully initiate and execute the infrastructure projects. Moreover, Zidane and Andersen (2017) sub categorized the internal administrative procedures into administrative demands, search after documents for archives, unnecessary or unclear reporting and annual budgeting and these factors are highly related to the administrative processes within the project organizations well as to the internal processes of the external organizations such as government institutes. Hence, these internal administrative processes can be streamlined by adapting the concepts such as lean in order to reduce the administrative wastes in the processes.

5. CONCLUSIONS

Among the limited studies conducted on administrative causes for delays in infrastructure projects, significant factors have emerged. These include delays in government consents and approvals, executive bureaucracy within the client's organization, slow decision-making, complexities and delays in administrative procedures, administrative delays within governing authorities, bureaucracy within the client's organization, scarcity of human resources for contract design, monitoring, and administrative tasks, extensive administrative involvement in contract management along with labor shortages, governance and administrative processes, extensions of administrative processes for approvals, administrative issues and delays, scheduling delays due to administrative procedures, internal administrative processes, bureaucracy within the project organization, institutional and administrative system factors, and political influences. These factors are identified as pivotal administrative causes contributing to delays in infrastructure projects. Further, both internal and external environment should concern on administrative causes which lead to project delays. To effectively tackle the administrative challenges influencing infrastructure projects, specific domains necessitate further examination. Employing the principles of lean concept can optimize internal administrative workflows within both project and external organizations. Further, in macro level, proper changes in regulations can be proposed with aiming to time and cost worthiness of the infrastructure projects.

6. CONTRIBUTION AND THE WAY FORWARD

This study contributes to the theory by exploring the administrative causes affecting to delay the infrastructure projects and sub categories of the identified administrative causes. Further, the administrative causes can be grouped in to externally or internally originated administrative processes. In addition, the practical contribution will achieve by remedial actions to reduce either internally originated administrative causes and make aware the necessary external parties for improve their internal processes related to the infrastructure project delays. While lean processes find application in various sectors, this study pioneers the adaptation of lean principles to enhance the efficiency of internal administrative procedures within infrastructure development projects, encompassing both project organizations and external entities involved in project management.

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