A FRAMEWORK TO SUPPORT RISK-SENSITIVE URBAN DEVELOPMENT IN SRI LANKA

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DEDICATION

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ABSTRACT

A framework to support risk sensitive urban development in Sri Lanka

Risk-sensitive urban development is an innovative planning approach that can transform the way cities are built in order to face the uncertainties that arise from climate-induced disaster risks. Even though, there are many actions taken by individuals, households, communities, urban development companies and relevant regulatory bodies to manage the disaster risks generated related to urban development, the disconnection between the existing urban development process and urban risk management process leads to the destruct the effort. Therefore, urban developers and disaster risk managers should understand each other and collaborate in order to provide a solution for this disconnection and this research provides a solution by proposing a risk sensitive urban development approach for Sri Lanka.

In order to identify the state of the art in risk sensitive urban development, a systematic literature review has been carried by adopting PRISMA method. Interpretivism stance has been used as research philosophy, where qualitative survey was adapted as the main research strategy. Semi structured interviews, focus group discussion and expert interviews were used as data collection techniques and purposive sampling method were chosen when selecting the sampling method. Manual content analysis and user story mapping were used, as the data analysis techniques to identify the current disaster risk management process used in Sri Lankan urban development projects and capture the user's requirements for an effective risk sensitive urban development approach in Sri Lanka. Finally, a framework has been developed to support risk sensitive urban development in Sri Lanka and expert interviews has been carried to validate the framework.

Under the state of the art in risk sensitive urban development 20 approaches; 3D ecological footprint model, EASI, smart urban plans, climate change risk assessment tools, community engagement, EWS, BIM based information system, etc. have been identified from the systematic review. In managing disaster risks in urban development projects, several approaches have been identified, which are currently used in disaster risk identification, assessment, mitigation and monitoring stages. Moreover, stakeholders involved in risk sensitive urban development such as UDA, DMC, NBRO, Irrigation department, SLLDC, etc. have been explored and their requirements for an effective risk sensitive urban development approach in Sri Lanka have been identified from the interviews. Further, 24 user requirements have been prioritised from the focus group discussion. Some of the key user requirements are identify the past records of disasters, indentify the vulnerable areas for each disaster, receive contact details of authority representative etc. The framework has been further validated using expert interviews. The framework will support the stakeholders involved with disaster risk management and urban development and will be beneficial to achieve risk sensitive urban development in Sri Lanka.

Keywords: Risk sensitive urban development, State of the art, Disaster risk management, User requirements, Urban development projects.

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CHAPTER 1

1.0 INTRODUCTION

1.1 Background

Urbanisation is one of the key challenges facing Sri Lanka today and Western province will be a prime urban hub of South Asia in future (Antalyn & Weerasinghe, 2020). UN-HABITAT (2021) has stated that Sri Lanka is rapidly urbanising with at least 50% by 2050. Populations in rural areas move to cities in search of employment and better living conditions since there are existing infrastructure encourages investment in industry and commerce; increased standards of health and nutrition; increased life expectancy and lower infant mortality; the perception that the city offers better education, training, employment and leisure opportunities; and the occurrence of natural and human induced hazards in rural areas (Malalgoda & Amaratunga, 2015b). Matsuoka and Shaw (2014) have explored that urban population, urban setting, urban structures, compact urban forms, urban dependance on rural areas, urban primacy, urban informal settlement, urban economic imbalances, urban services, urban natural environment, urban built environment, and urban governance and management lead to urban risks and major challnges for Asian countries in future. According to Deely, Dodman, Hardoy, and Johnson (2010), people are concentrating in large cities with poor housing with lack of basic protective infrastructure, hence will cause to generate higher urban risks. Further, the authors fear that this urban risk may be a major challenge for humankind in the 21st century.

Sri Lanka has seen a substantial rise in the frequency and severity of natural disasters over the last few decades (Amaratunga & Haigh, 2020). As a developing country, Sri Lanka has faced several natural disasters such as coastal erosion, droughts, floods, landslides, lightning, sea level rise, storm surge, tropical cyclones and tsunamis and approximately 500,000 people were affected a year, out of which 90% was due to floods (Malalgoda & Amaratunga, 2015b). The western province in Sri Lanka has been recognised as the most populated, economically active and the fastest developing

region. Colombo consists 14 local authority areas, and has projected a population of 3.5 million by 2030 due to the issues in rura1 areas and the benefits of improved living styles in the urban area (Urban Development Authority [UDA], 2019).

However, UDA explored that the increased population in urban areas has badly affected the environmental system and has caused to the disaster risk increasement due to this rapid growth of the urban development projects in Colombo area. Specially Sri Lankan urban areas get severely damaged and face greatest level of risks than the other areas, since urban areas highly depend on the infrastructure and money economy (United Nations International Strategy for Disaster Reduction [UNISDR], 2000; United Nations Human Settlements Programme [UNHSP], 2007). As such, it is very important to manage the disaster risks during the urban development projects before it affects the people severely (Bansal & Mukherjee, 2019). The Economist Intelligence Unit (2016) explored that, it is needed to focus on risk sensitive urban development to mitigate the urban risk before it affects to the people.

"Risk-sensitive urban development is an innovative planning approach that can transform the way cities are built in order to face the uncertainties that arise from climate-induced disaster risks" (Roslan, Fernando, Biscaya, & Sulaiman, 2021, p1). According to United Nations Economic and Social Council (2015) risk-sensitive development involves integrating disaster risk reduction into development planning across all sectors of development that help to protect gains made towards achieving development goals. Furthermore, it is promoted in order to reduce existing risk in the city and to properly address risk while planning new developments, which is typically done in the context of uncertainties and threats (Jones & Preston, 2011). Under the risk sensitive urban development, it is focused on more appropriate building design, construction and land-use planning, enhanced infrastructure access and maintenance, risk awareness raising, and planning for emergency response and reconstruction including social safety nets and insurance (Leck et al., 2018a). There are several frameworks such as Sendai framework, Hyogo framework, Community Resilience Framework (CRF) and Sri Lanka Comprehensive Disaster Management Programme

(SLCDMP) which provide guidance to risk sensitive urban development projects in Sri Lanka (Saja, Sahid, & Sutharshanan, 2020b). Those frameworks have identified and designed several strategies such as hazard vulnerability and risk assessment, risk knowledge and risk governance, policy environment and legal/institutional framework, multi-hazard early warning and effective dissemination, disaster mitigation and DRR mainstreaming into development, reconstruction and rehabilitation, training and awareness, preparedness and response, and monitoring and evaluation which can be used for a risk sensitive urban development.

Risk assessment is the basis of urban development planning and it is the starting point for vulnerability reduction (Asian Disaster Preparedness Center, 2007). Therefore, when considering the risk sensitive urban development projects, risk assessment information is very important for authorities and communities to determine the risks they have to face, the degree of the identified risks, the actions need to be taken, and the resources required in order to face and mitigate the future risks (Tran, Kaneko, Shaw, Victoria, & Oi, 2009).

There are many actions taken by individuals, households, communities, urban development companies and relevant regulatory bodies to manage the risk through the risk sensitive urban development methods. However, there are gaps between what they have expected and what they have accomplished under risk sensitive urban development. The ability of urban cities to effectively manage their urban risks and well-being of the population, sustain balanced growth, and tackle climate change impacts is not only determined by sector legislation but also by the framework of outdated urban regulations that is still in force (Asian Development Bank, 2015a). Moreover, it has been explored that, there is a disconnection between the existing urban development projects and urban risk management process. Pelling, Brown, Lwasa, and Chen, (2017) has also pinpointed that urban planning in many parts of the world, but particularly in developing regions, has become increasingly disconnected from contemporary urban challenges linked to rapid urbanisation, poverty, informality, spatial fragmentation and climate change. As a result of this disconnection

between the urban development and risk reduction activities, urban disaster risks have grown faster than the reduction rate (UNDRR, 2013). Therefore, new and more inclusive risk sensitive urban development approaches need for sustainable future.

1.2 Problem Statement

As stated in the background, unplanned urban development leads to generate various physical, social and economic vulnerabilities. Moreover, urbanisation with unplanned urban growth has affected to produce disaster risks because of inadequate capacity, unstable governance structures, and substandard infrastructure, built-environment, and urban services (Gencer *et al*., 2018). Malalgoda and Amaratunga (2015b) have empahsised that major economic activities are handled in urban areas and it making the country more vulnerable to disasters. In order to mitigate the risk of disasters, stable strong policies and disaster risk reduction measures have been taken, but need to determine the suitable initiatives to mitigate disaster risk, especially in urban areas (Tran et al., 2009).

However, many aspects of prevailing urban planning and development make a contribution to vulnerability, because urban developers have given their focus to the investment rather assessing the risks related to the projects (UNDRR, 2013). Dickson, Baker, Hoornweg, and Asmita (2012) stated that lack of technical skills, lack of financial resources, less political support and lack of data caused to discourage the urban developers to do a disaster risk assessment. Moreover, climate change impacts needed to be considered in the overall urban risk management since climate change caused to increase the risks related to the development (Matsuoka & Shaw, 2014). As a result of these issues, it leads to disconnect the collaboration between the urban development and risk mitigation activities (Asian Development Bank, 2015a).

In order to mitigate the disconnection between the urban development approaches and risk reduction activities, risk sensitive urban development should be incorporated to the urban development projects (United Nations Economic and Social Council, 2015).

Risk sensitive urban development can be defined as the way of transform the urban areas with resistant to the critical disaster (Kohler, Jülich, & Bloemertz, 2004).

In Sri Lankan context, even though the professionals had done several risk reduction activities, Sri Lankan people, especially those live in urbanised areas, are still facing disasters yearly in terms of damage to themselves and their properties (Siriwardana, Jayasiri, & Hettiarachchi, 2018a). Moreover, Randil, Siriwardana, and Hewawasam (2020) also emphasised that still there are loopholes in Sri Lankan disaster management approaches and the central government and other relevant parties have to take further actions to mitigate disaster risks in urban areas. With the intention to provide a solution for this issue, this study intends to explore suitable risk sensitive urban development approaches that can be used in Sri Lankan urban development projects. Figure 1.1 simply shows the research problem of this study, where it highlights the lack of colloboration between the urban development authorities that tend to increase risks and disaster management authorites that intends to reduce risks.

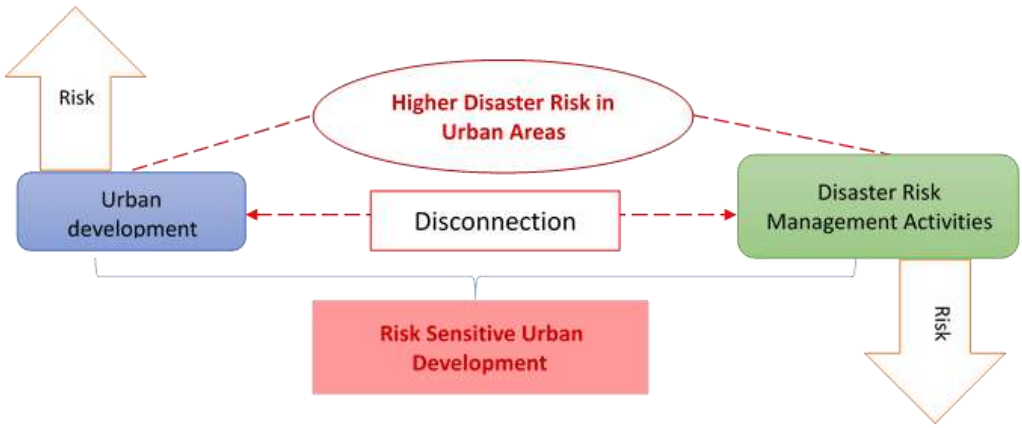


Figure 1.1: Research Problem

1.3 Aim and Objectives

Aim

The aim of this research is to develop a framework to support risk-sensitive urban development in Sri Lanka.

Objectives

The aim of this research was achieved through the objectives given below.

1. To review the state of the art in risk-sensitive urban development.
2. To explore the current process used to identify, assess and manage disaster risks in urban development projects in Sri Lanka.
3. To capture the user requirements for an effective risk-sensitive urban development approach in Sri Lanka.
4. To device suitable components from the analysed data for a framework for supporting risk-sensitive urban development in Sri Lanka.

1.4 Research Methodology

A qualitative research approach was most suitable to achieve the aim of developing a framework to support risk-sensitive urban development in Sri Lanka. The qualitative research approach is exploring the phenomena by focusing on values, opinions, behaviours and social context, while quantitative approach is seeking to confirm hypotheses about phenomena (Cropley, 2019). This study intended to explore the risk sensitive urban development approaches in the context of Sri Lankan urban development projects by capturing the user requirements, views and opinions of stakeholders related to risk sensitive urban development. Therefore, qualitative research approach was adopted to this study. As the objectives of the research has an exploratory nature, a survey strategy was more suitable to capture the knowledge across a wider context. Generally, a qualitative survey is used to develop a deep understanding of a topic, issue, or problem from an individual perspective. In order to

achieve the objectives of this study, qualitative survey method was supported to capture the user requirements and their individual perceptions on risk sensitive urban development. Hence this study adopted a qualitative survey as the main research strategy.

According to the established objectives, the research first reviewed the state of the art in risk sensitive urban development in a global and local context. A systematic review of literature was carried out to achieve the first objective. In addition, narrative literature review was undertaken to gain further knowledge and understanding on the subjects while the research progresses with the rest of the objectives. The findings from first objective were contextualised to the Sri Lankan urban development to understand the process through which disaster risks are considered, assessed and managed. Semi-structured interviews with key stakeholders of disaster management and urban development authorities were the main methodology used to address the second objective and third objective. Further the research was intended to capture the different user requirements of each stakeholder to evaluate the effectiveness of current risk sensitive urban development approaches. In order to prioritize the captured user requirements, focus group discussion was conducted.

Finally, suitable components were devised by analysing the data collected from objective 1, 2 and 3 to develop the framework, where the existing risk sensitive urban development approaches was evaluated with the captured user requirements in the context of urban development projects in Sri Lanka. Expert interviews were conducted to validate the final framework.

To facilitate data collection, purposive sampling was selected since the data to be collected from selective experts who have knowledge and experience in dealing with risks and risk sensitive urban development approaches in urban development projects in Sri Lanka. Qualitative content analysis and user story mapping were adopted as the data analysis techniques for the data collected using semi-structured interviews.

1.5 Scope and Limitation

The aim of this study is to develop a framework to support risk sensitive urban development in Sri Lanka. There are several types of risks such as disaster risk, capital risk, social/cultural risk, economic risk, institutional and policy risk affect to the urban development projects. Among the aforementioned risks, the scope of the study has been narrowed down to consider only the disaster risk when developing the framework.

1.6 Chapter Breakdown

The study is organised under five chapters as follows;

Chapter 01- Introduction

Chapter 1 introduces the background of the study and defines the research problem with aim, objectives, methodology outline as well as the structure of the study.

Chapter 02- Literature Review

The initial literature review is conducted as a systematic review based upon journals, web sites, books, dissertations, conference papers and other publications. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement that is specifically introduced for reliable systematic reviews will be utilised.

Chapter 03- Research Methodology

This chapter contains the methodological design that is used to carry out the study.

Chapter 04- Data Collection, Analysis and Discussion

Chapter 04 includes the data collection process conducted through expert interviews and user stories. The collected data will be analysed through content analysis and estimations of user stories. The key outcomes are outlined and the discussion is conducted on the research findings by revisiting the literature at the end of this Chapter.

Chapter 05- Conclusions and Recommendations

The conclusions from the findings and recommendations were presented in this chapter with the recommendations for further studies.

1.7 Chapter Summary

This chapter describes background study, problem statement, aim and objectives, research methodology, scope and limitation. Finally, the chapter breakdown is described to get a better idea about the study.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Introduction

The previous chapter identified the research aim and objectives through the background study. This chapter reviews the literature on state of the art in risk sensitive urban development approaches to develop a framework to support risk sensitive urban development projects in Sri Lanka. Initially, narrative literature review was carried out as a foundation to the research and enlighten all the objectives. Moreover, a systematic literature synthesis was conducted by adopting Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) mainly to explore the state of the art in risk sensitive urban development approaches used in urban development projects.

2.2 Urbanisation

Urbanisation plays a major role in the economic development of every country since it has a mutual relationship between the urbanisation and productive economic structure (Clemente, Strano, & Batty, 2021). Sanyaolu and Okosun (2018) defined the urbanisation as the way of population shift from rural areas to urban areas or the gradual increasement in the proportion of people living in urban areas. Urban population in 2020 was represented as 56.2% from the world population and it is expected to increase to 68.6% by the year 2050 (Worldometer, 2022). Table 2.1 shows the world population forecast with the urban population increasement.

Table 2.1: World Population Forecast

Year	Total Population	Urban Population	Urban Population Rate (%)
2020	7,794,798,739	4,378,993,944	56.2 %
2025	8,184,437,460	4,774,646,303	58.3 %
2030	8,548,487,400	5,167,257,546	60.4 %
2035	8,887,524,213	5,555,833,477	62.5 %
2040	9,198,847,240	5,938,249,026	64.6 %
2045	9,481,803,274	6,312,544,819	66.6 %
2050	9,735,033,990	6,679,756,162	68.6 %

(Source: Worldometer, 2022)

According to Table 2.1, the urban population will be gradually increased with the increasement of world population. Furthermore, Sri Lanka has become 58th place according to the world population and 18.4% of them live in urban areas by 2020 (Worldometer, 2022). As a result of this higher urbanisation, many challenges and consequences may affect the people and the country.

2.3 Consequences of Urbanisation

Urbanisation is the main step taken by the community to get improved their living conditions. Higher level of urbanisation can be seen in developing countries and many problems have been occurred due to the negative impacts of the urbanisation.

Gu (2019) has pinpointed that urbanisation is a sign of modernisation, which develops the country economic condition, creates different urban forms, enhance production technologies, changes the lifestyles of people, and enhance the social values in the country. Moreover, urbanisation caused to modernise rural communities, increase their knowledge, create cultural collaboration, and cooperation between rural communities and urban communities (Sasana, Prakoso, & Setyaningsih, 2019). However, few researchers have identified the positive side of the urbanisation and majority of the

researchers have highlighted the negative impacts of urbanisation. Table 2.2 shows the positive and negative impacts of urbanisation.

Table 2.2: Positive and Negative Impacts of Urbanisation

Positive Impacts	Negative Impacts
▪ Economic and institutional innovations ▪ Cultural development ▪ Educational development ▪ Employment and health development ▪ Agglomeration of people and enterprises ▪ Reduce production cost ▪ Reduce transaction cost ▪ Easier access to finance ▪ Promote business ideas ▪ Easy to find skilled labor	▪ Poor quality housing ▪ Environment pollution ▪ Crimes ▪ Traffics ▪ Disrupt the flow of materials ▪ Disrupt the energy and information ▪ Disrupt structures and functions of the eco system ▪ People depend on others for basic necessities ▪ Social problems ▪ Cultural conflicts ▪ People compete for limited resources ▪ Poverty ▪ Poor sanitisation ▪ Difficult to manage seepage ▪ Issues in waste water treatment and disposal ▪ Disaster increasement ▪ Poor food security ▪ Scarcity

Sources: (Nguyen & Nguyen, 2018; Cui, Feng, Han, & Guo, 2019; Kookana, Drechsel, Jamwal, & Vanderzalm, 2020; Aziz, Hassan, & Saud, 2012)

In the Sri Lankan context, city development and planned urbanisation have been recognised in key government plans and strategies as being intrinsic to its future development trajectory since urban-centred development is projected as the means to elevate Sri Lanka to a ‘high income country’ from its current ‘middle income’ status (Mendis, 2019). Kookana et al. (2020) revealed that people who are lived in Sri Lankan urban areas are facing critical issue in sewerage water management and solid

waste management. Accordingly, there are many adverse effects of rapid urbanisation and it brings many challenges to the people live in urbanised areas. Accelerated demand for affordable houses, job competition, transportation issues, basic infrastructure issues were highlighted as the major challenged faced by the people live in urban areas.

2.4 Urban Development Projects

Urban development projects or urban transformation projects can be identified as an important method to solve the problems generated because of the rapid urbanisation (Yavuz, 2016). Urban development projects focus the development of social, cultural, economic and physical aspects in a city. Furthermore, it provides infrastructure for education, health, justice, waste management, markets, street pavements and cultural heritage protection for the people who are living in urbanised areas (European Union, 2022).

According to Urban Development Authority Sri Lanka (2021), there are several urban development projects initiated in Sri Lanka and summary of such projects are shown in Table 2.3.

Table 2.3: Urban Development Projects in Sri Lanka

Project Name	**Project Details**
100 Cities Project	The project has already started and it is focused 100 towns that required physical improvement. The main objectives of the program will be, • To implement basic infrastructure development projects to facilitate the local economy. • To implement town beautification projects in order to enhance a liveable urban environment in identified towns <u>Project Locations</u>: Colombo (Kotikawatta, Hanwella, Padukka, Ebulgama, Kaduwela , Vidyala Junction, Moratuwa) ; Gampaha (Peliyagoda, Ekala, Awariyawatta, Minuwangoda, Henagama, Mirigama, Divulapitiya, Ganemulla, Pugoda, Attanagalle); Kaluthara (Horana, Nagoda, Dodangoda, Meegahathenna); Galle

	(Kumarakanda, Ambalangoda, Habaraduwa, Baddegama, Bentota; Mathara (Deiyandara, Morawaka, Pitabeddara, Deniyaya, Weligama, Kamburupitiya); Hambantota (Weerawila, Ranna, Chithragagala, Nonagama, Angunukolapelessa, Lunugamwehera); Rathnapura (Kuruwita, Ayagama, Nivigala, Godakawela, Balangoda); Kegalle (Rambukkana, Galigamuwa, Bulathkohupitiya, Moronthota, Hemmathagama); Kurunegala (Kobeigana, Ambanpola, Hiripitiya, Bingiriya, Alawwa, Hettipola, Pannala, Polgahawela, Bambukkatuwa); Puttalam (Chilaw, Thoppuwa, Palavi); Anuradhapura (Thirappane, Kekirawa, Eppawala, Kajugollewa, Anuradhapura); Polonnaruwa (Aralaganwila, Medirigiriya, Welikanda, Jayanthipura); Kilinochchi (Kilinochchi, Poonariyan); Mannar; Vavunia; Jaffna (Muruthanarmadam, Velanai); Mullativu (Welioya); Kandy (Kandy, Digana, Wattegama, Pupuressa, Muruthalawa, Theldeniya, Nawalapitiya); Nuwara Eliya (Ginigathhena, Thalawakele, Ragala, Rikillagaskada); Matale (Matale, Inamaluwa, Pallepola, Ukuwela, Naula); Trincomalee (Kantale, Muthur); Batticaloa (Vantharumoolai, Urani); Ampara (Mahaoya, Hingurana, Dehiattakandiya, Kalminai); Badulla (Bandarawela, Beragala, Giradurukotte); Monaragala (Kataragama, Wellawaya, Thanamalwila, Sevanagala, Ethimale, Okkampitiya)
High Rise Mixed Development	• Welikada Prison Land at Borella • Land at Battaramulla Town Centre • Charmers Granaries Land at Colombo Fort • Land at Galle Town Centre • Land at Nugegoda Town Centre
High-end Boutique Hotel Development Project	• Land at Union Place, Visumpaya Premises • Land at Torrington Square (80 Club), Colombo 07
Logistic Facilities and Business Park Development Project	Former Sri Lanka Broad Casting Cor. (SLBC) Land at Ekala Town Centre, Ja Ela

(Source: Urban Development Authority Sri Lanka, 2021)

Urban developers must take immediate actions to manage the expected future growth and provide the basic services, infrastructure, and affordable housing facilities. Urban development projects consist of four stages; pre-design stage, design or development stage, use or management or maintenance stage and decline or demolition stage (Wootton, 2020). The activities carried out in the process of urban development project are shown in Table 2.4.

Table 2.4: Process of Urban Development Project

Development Stage	**Activities**
Pre- Design Stage	Identify the need for an urban development project
	Site selection (Site survey and valuation of surrounding sites)
	Decide project objectives
	Fund allocation
	Project team selection
	Decide project time scale
Design and Development	Project design preparation
	Material extraction (Importation and transportation)
	Labour allocation
	Landscaping
	Site clearance
	Construction
	Equipment Demobilization
Use, Management and Maintenance	Operation Management
	Maintenance
Decline and Demolition / Regeneration	End of the usage

(Source: Wootton, 2020)

According to Table 2.4, there are four main stages under the urban development process such as pre-design stage, design and development stage, use or maintenance or management stage and decline or demolition or regeneration stage.

2.5 Risks of Urban Development Projects

Disasters are the major hazard faced by both low and middle income countries frequently (Dickson et al., 2012). According to the recent disasters happened in Haiti and Indonesia (earthquake), Myanmar and China (cyclone) caused to increase the death rate in developing countries (Dickson et al., 2012). Moreover, unplanned urbanisation have caused to generate traffic congestion, waste resources, limited social services, environment pollution, water scarcity, and confusion in land-use patterns (Zoysa, 2021). Therefore, urban development projects play an important role under climate change mitigation process, because of the relationship between the climate change and the disaster risk (The World Bank, 2020).

In addition to that, urban development projects have caused to increase in flood risk, since urban development projects have caused to change the topography of the environment by expanding the impermeable areas, which prevent rain from being absorbed by the soil (UNDRR, 2013). Weak regulations, lack of enforcement in building codes, poor plans in the urban development projects transfer the risk to the people who are living in urban areas. Moreover, increased urban development projects pressure can cause settlement growth in hazard prone areas and can destroy natural protective ecosystems that have historically mitigated the risks of landslides, flooding, and storms (UNDRR, 2019). .

2.6 What is Urban Risk?

Urban risk is an unexpected occurrence of failure of any functioning or management operations that are harmful to life, social and economic activities in urban areas (Teja, 2021). Table 2.5 describes the urban risk driving factors.

Table 2.5: Urban Risk Driving Factors

Factor	Description	References
Urban population	Due to the obvious unplanned expansion of cities with high population density in developing countries, urban populations are exposed to natural disasters.	(Hossain, Spurway, Zwi, & Huq, 2017)
Urban setting	Due to the poor regulations of construction, inadequate infrastructure and poor industrial practices caused to create man made hazards in urban (e.g. the 2013 garment factory collapse in Bangladesh, the garbage slide in an informal settlement in Meethotamulla).	(UNDRR, 2013)
Urban structures	Due to the expansion of urban areas, it creates challenge to natural resource utilisationa and waste generation.	(Matsuoka & Shaw, 2014)
Compact urban forms	Due to business and recreational areas, city density fluctuates greatly during the day and at night. When a large number of individuals are confined to a small space, even a minor but destructive occurrence has the potential to injure a larger number of people.	(H. Yan et al., 2021)
Urban dependence on rural areas	There is a close connection between the urban areas and rural areas and both depends themselves. Either o1ne of them affected by a disaster, it affects both adversely.	(Matsuoka & Shaw, 2014)
Urban primacy	Urbanisation could cause a country's entire disruption if a large hazardous event occurs in such a urbanised area.	(Moomaw & Alwosabi, 2007)
Urban informal settlement	Urban informal settlement will caused to poor sanitation, overcrowding, poor housing, physical hazard, pollution, and poverty.	(Zerbo, Delgado, & González, 2020)
Urban economic imbalances	Poverty is caused to live in hazardous environments, such as susceptible housing, degraded environmental conditions, and hazardous places.	(Nijman & Wei, 2020)

	People react to disasters in different ways. The poorest people are severely affected by disasters and are difficult to fully recover from their losses.	
Urban services	Smart technologies required to solve the issues in large scale building services network used for urban areas.	(UNDP, 2010)
Urban natural environment	Urban risk may be increased because of the urbanisation caused to degrade the environment, loss of bio diversity and disrupt to economic imbalances.	(Dickson et al., 2012)
Urban built environment	The vulnerability of human settlements in an urban region is mostly determined by safety elements incorporated in the building mass in relation to specific hazards, such as earthquake-resistant construction and cyclone-resistant construction. Poor land-use planning can also result in disasters.	(Leck et al., 2018a)
Urban governance and management	The challenges of managing cities as a result of complex socioeconomic processes including heterogeneous societal structure.	(Matsuoka & Shaw, 2014)

In most of the cities there are no measures taken to adopt new regulations for continuously evolving new urban risks in light of climate change and increased disaster events (Bansal et al., 2013). Furthermore, the poor people are the weakest section in the social structure and any adverse condition will affect them very first and severely damaged them due to their inadequate living conditions, difficulties to access to basic services and sanitation, poor health conditions, negligible literacy (Moomaw & Alwosabi, 2007; Zoysa, 2021).

2.7 Types of Urban Risk

Based on the degree of exposure and coping capability, urban risks can be classified as follows (Bansal et al., 2013).

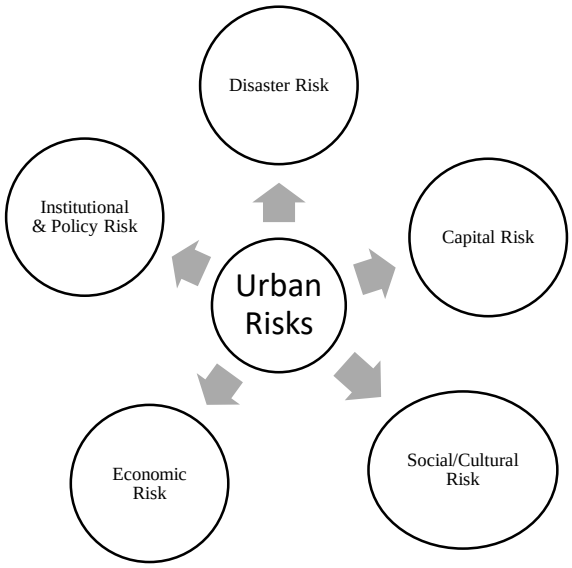


Figure 2.1: Types of Urban Risk

The urban risk types are further elaborated below.

2.7.1 Disaster risks

According to UNDRR (2013), disaster risk can be defined as the probability of having an injury, loss of life and damaged assets because of the hazard in the environment. As the global population grows and migrates to urban areas, disaster risks are increasing and becoming more severe when developing cities transfer into the megacities (Cutter, 2021).

Project Management Institute (2018) has presented the life cycle of an urban development project. Accordingly, the project life cycle is consisted 5 distinct phases including initiation, planning, execution, monitoring, and closure that transfer any project idea into a completed product. However, urban development project increase the disaster risks and Table 2.6 presents the disasters generated in the process of urban development projects.

Table 2.6: Disaster Risks in Urban Development Projects

	Disaster Risks	Urban Development Process				Literature Sources
		Pre-Design Stage	Design and Development Stage	Use, Management and Maintenance Stage	Decline and Demolition / Regeneration	
DR01	Rapid urbanisation	✓		✓		[2] [16] [20]
DR02	Land competition	✓			✓	[6] [16][20]
DR03	Decreased vegetation cover	✓	✓		✓	[6] [16] [20]
DR04	Changes in land use	✓	✓			[6] [16] [20]
DR05	Climate change	✓	✓	✓	✓	[16] [19] [20]
DR06	Poverty and inequality		✓	✓		[1] [20] [19]
DR07	Unsustainable uses of natural resources	✓	✓	✓		[1] [3] [7] [19]
DR08	Declining ecosystems	✓	✓	✓	✓	[5] [10] [19]
DR09	Pandemics and epidemics			✓		[11] [19]
DR10	Forest fire	✓	✓		✓	[4] [8] [19]
DR11	Soil erosion	✓	✓		✓	[1] [5] [8] [11] [15] [19]
DR12	Land contamination	✓	✓	✓	✓	[10] [18]
DR13	Poor local governance	✓	✓	✓		[2] [11] [18]
DR14	Environmental degradation	✓	✓	✓	✓	[11] [15] [18]
DR15	Inappropriate land use planning	✓	✓			[9] [14] [18]

DR16	Failure to regulate building standards	✓	✓	✓		[12] [13] [18]
DR17	Poor health			✓		[10] [11] [18]
DR18	Inadequate nutrition			✓		[9] [18] [22]
DR19	Illiteracy			✓		[3] [7] [18]
DR20	Deficient or non-existent sanitation	✓		✓		[1] [11] [17]
DR21	Over extraction of water	✓	✓	✓		[1] [6] [17]
DR22	Clay soil shrinkage	✓	✓			[1] [10] [11]
DR23	Water pollution	✓	✓	✓	✓	[1] [6] [11]
DR24	Marine pollution	✓	✓	✓	✓	[1] [6] [11]
DR25	Topography changes	✓	✓			[1] [6] [11]
DR26	Lack of adequate infrastructure and services,	✓	✓			[1] [11] [17]
DR27	Carbon emission	✓	✓	✓	✓	[21] [11] [17]
DR28	Heat island effect	✓	✓	✓	✓	[6] [11] [21]
DR29	Air pollution	✓	✓	✓	✓	[6] [11] [21]
DR30	Water scarcity	✓	✓	✓		[1] [6] [10]
Disaster Risks	Count	25	23	21	13	
	%	83%	76%	70%	43%	

Literature Sources: [1](Asian Development Bank, 2015b), [2](Asian Disaster Preparedness Center, 2007), [3] (Aziz et al., 2012), [4](Bello, Bustamante, & Pizarro, 2021), [5](Cui et al., 2019), [6](Dickson et al., 2012), [7](Dociu & Dunarintu, 2012), [8] (Edgell, 2020), [9](Gencer et al., 2018) [10] (Kookana et al., 2020), [11](Leck et al., 2018b), [12](Organisation for Economic Cooperation and Development, 2012), [13](Roslan et al., 2021), [14](Saja, Sahid, & Sutharshanan, 2020a), [15] (Shaw, Srinivas, & Sharma, 2009), [16](The World Bank, 2022), [17](Trenouth, Gharabaghi, & Farghaly, 2018), [18](UNDP, 2010), [19] (UNDRR, 2022), [20](Wootton, 2020), [21](World Economic Forum, 2020), [22](Zerbo et al., 2020)

According to Table 2.6 majority of the disaster risks have been identified during the pre-design stage (83%). During the design or development stage, operation or management stage and the demolition stage 76%, 70% and 43% of the disaster risks have been identified respectively.

Organisation for Economic Cooperation and Development (2012) has categorised disaster risks into four types as follows.

- Environmental/Climate related disaster risks
- Urban development related disaster risks
- Economic & Social related disaster risks
- Institutional/governance related disaster risks

Accordingly, disaster risks identified in Table 2.6 can be allocated as per the above categorisation as shown in Table 2.7.

Table 2.7: Disaster Risk Categorisation

	Disaster Risks	Disaster Risk Category			
		Environmental/Climate related disaster risks	Urban development related disaster risks	Economic & Social related disaster risks	Institutional/governance related disaster risks
DR01	Rapid urbanisation		✓		
DR02	Land competition		✓		
DR03	Decreased vegetation cover		✓		
DR04	Changes in land use		✓		
DR05	Climate change	✓			
DR06	Poverty and inequality			✓	
DR07	Unsustainable uses of natural resources		✓		
DR08	Declining ecosystems	✓			
DR09	Pandemics and epidemics	✓			
DR10	Forest fire	✓			
DR11	Soil erosion	✓			
DR12	Land contamination	✓			
DR13	Poor local governance				✓
DR19	Illiteracy			✓	
DR20	Deficient or non-existent sanitation			✓	
DR21	Over extraction of water	✓			
DR22	Clay soil shrinkage	✓			
DR23	Water pollution	✓			

DR24	Marine pollution	✓			
DR25	Topography changes	✓			
DR26	Lack of adequate infrastructure and services,				✓
DR27	Carbon emission	✓			
DR28	Heat island effect	✓			
DR29	Air pollution	✓			
DR30	Water scarcity	✓			
Disaster Risks	Count	15	5	3	2
	%	50%	17%	10%	7%

According to Table 2.7 majority of the disaster risks have been categorised under the environmental/climate related disaster risks (50%).

2.7.2 Capital risk

Capital risk refers to the probability that an organization will lose money on a capital investment(The Norinchukin Bank, 2009). Accordingly, when developing an urban development project, it will caused to damage to the government buildings, essential facilities, lifeline and utilities, machinery, equipment and furnishing (Bansal et al., 2013). Those damages are considered as capital risks affected in urban areas.

2.7.3 Social/ Cultural risk

As per the Bansal et al. (2013), urban development projects generate social and cultural risks to the society. During the urban development project process, unsafe and unplanned construction methods may cause for human death and injuries. Due to the increasement in the urban development projects, people live in the planned development areas have changed their houses and it generates many cultural issues to the society (X. B. Liu, Wang, & Li, 2021).

2.7.4 Economic risk

Urban development projects generate many economical risk such as financial losses to government and businesses in the country, because of the tax rate reduction plans implemented by the government to motivate the development sector. (Bansal et al., 2013).

2.7.5 Institutional and policy risk

In order to be resilience from natural hazards and climate change risk, good governance including institutional arrangements, supporting policies and legislation should incorporate with the development plans (African Development Bank, 2013). According to Bansal et al. (2013), below risks have been identified as institutional and policy risks which lead to generate risks in urban areas.

- Liabilities of the government
- Staff turnover
- Damage to reputation
- Erosion of community vision and undermining of other policies

Strong and well organised policies provide a proper guidance for an effective urban development projects and it is essential to manage aforementioned risks to achieve sustainable urban development (African Development Bank, 2013).

2.8 Why Disaster Risk is Critical in Urban Development Projects?

Due to the relationship between the urbanisation and climate change, it creates challenges for urban residents and their lives by increasing the vulnerability level to extreme weather conditions and other natural disasters (Zoysa, 2021). Unplanned urban development projects also create new risks and it destroy the current development income. Moreover, lack of adequate infrastructure, unsafe housing, poor health services and poor waste management can transform natural hazard into a severe disaster (UNDRR, 2013). Since the less focus on the disaster risks management in the urban development projects, it creates greater fatalities and economic losses in urban

areas than rural areas. United Nations International Strategy on Disaster Reduction, (2009) declared that urban development projects create hazards, exposure and vulnerability by settling the communities in high-risk areas due to the rapid and uncontrolled urbanisation. (Dickson et al., 2012). Accordingly, people who live in urban areas have to face disasters yearly and they have been severely affected from the disasters as shown in Figure 2.2.

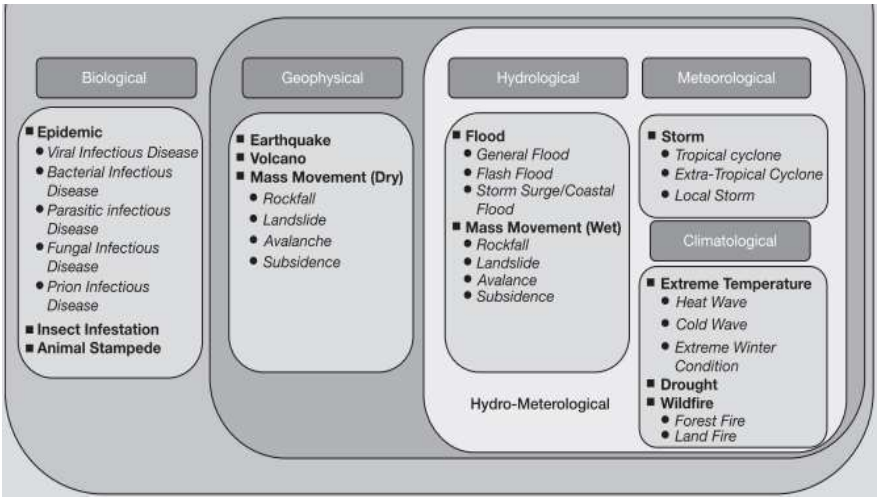


Figure 2.2: Disasters affect the urban development projects

Source: (Dickson et al., 2012)

. According to Figure 2.2, disasters such as flood, mass movement (wet), storm, extreme temperature, droughts, wild fire, earthquake, volcano, mass movement (dry), epidemic, insect infestation and animal stampede may affect the urban development projects. However, Malalgoda and Amaratunga (2015b) revealed that coastal erosion, droughts, floods, landslides, cyclones and tsunami are the key disasters generally affect to Sri Lanka and people live in urban areas face greater difficulties than in rural areas due to the increasement of urban development projects. Therefore, urban development projects should be strengthen more by adopting risk sensitive urban development approaches.

2.9 Risk Management Process

Risk is the likelihood or probability of harm or adverse effects resulting from a hazard or a combination of hazards, taking into account factors such as exposure and vulnerability (Weerasinghe et al., 2018). Therefore, the risk can be illustrated as Figure 2.3.

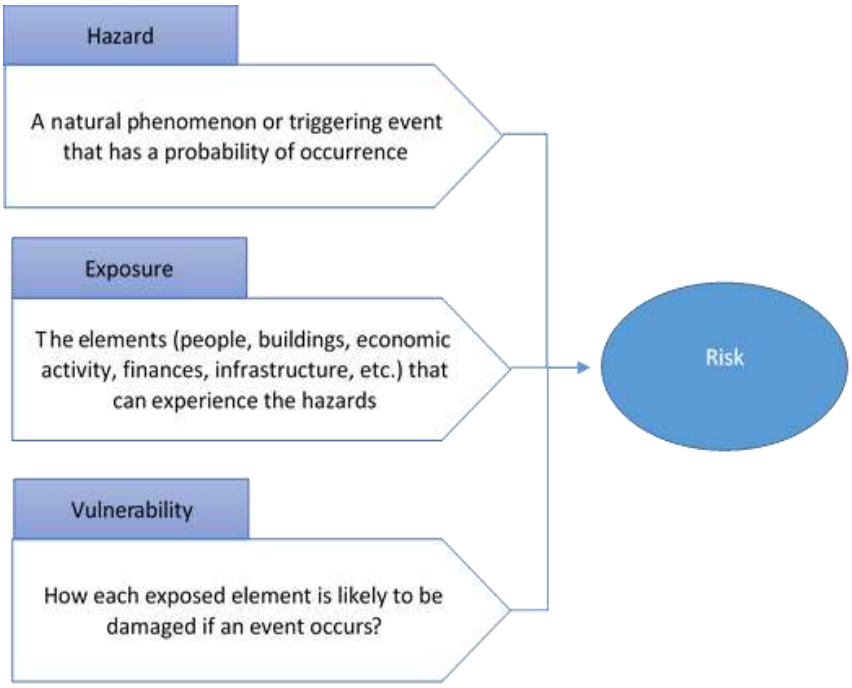


Figure 2.3: Risk Calculation

As per Figure 2.3. , risk depends on the hazard, exposure and vulnerability. Therefore, managing the disaster risk is essential for ensuring the long-term success and sustainability. Risk management is an organised methodology that analyses the associated potential consequences of events and formally provides policies, processes, and practices to mitigate the consequences of the event (Bansal et al., 2013). Thus, urban risk management process involves a logical and systematic method of identifying risks, analysing, assessing and quantifying risks; managing and implementing risk management decisions and implementation and monitoring the risks over time.Jones & Preston (2011); EMI (2006); Zerbo et al. (2020) have identified four (04) steps in the risk management process, namely: Step 1:

Identification, Step 2 Assessment and Quantification, Step 3: Risk management decisions, and Step 4: Risk monitoring. These steps are explained below.

Step 1: Risk Identification

Risk identification is the process of systematically identifying, describing, and documenting potential risks (Jones & Preston, 2011). There are several risk identification tools and techniques used in risk management process and some of them are presented in Table 2.8.

Table 2.8: Risk Management Tools and Techniques

Tool/Technique	**Description**	**Literature Resources**
Brainstorming	Brainstorming is a free and open approach which carries by group of people and encourages project team to participate into the risk identification process by giving their ideas and plans about disaster management.	(Wanner, 2019 ; McGevna, 2012)
Root Cause Analysis	Root cause analysis (RCA) is a method for identifying the "root causes" of problems or events and developing a strategy for dealing with them. RCA intends not only identify the potential risks, but also to determine why risk events occurred following significant loss.	(ASIS International, 2022; Fox, 2018; Brian, Mark, & Dennis, 2009)
SWOT Analysis	A SWOT analysis is a method of evaluating the operations' strengths, weaknesses, opportunities and threats of a project. Findings derived through this analysis the project team to identify risks related to the project and blind spots in the operation.	(Wilson, 2018; United States Department of Agriculture, 2008)
Risk Assessment Template	A risk assessment template is a tool used for identifying and controlling the project risks. Through a systematic analysis, hazards are identified to assess the likelihood and severity.	(Pimpin, 2022)

Risk register	A risk register is a database include the information about each risks affected to the earlier projects.	(Ray, 2021; Everitt, 2022)
Risk matrix	A risk matrix is used to assess the level of risk by comparing the probability or likelihood of a risk. It provides information about the critical risks affected to the projects.	(Glossop, 2021)

According to Table 2.8 brainstorming, root cause analysis, SWOT analysis, risk assessment template, risk register and risk matrix are used as the risk identification tools and techniques.

Step 2: Risk Assessment and Quantification

Risk assessment and quantification is important step in the risk management process that involve evaluating the potential risks identified during the risk identification process. Under this step, risk is analysed the likelihood and potential impact of each identified risk. This can be done using qualitative or quantitative methods, or a combination of both (Fox, 2018). Qualitative risk assessment based on expert judgment and subjective assessments, while quantitative risk assessment using data, models, and statistical analysis to quantify the risk. This information is used to prioritize risks and develop risk management strategies, such as risk avoidance, risk reduction, risk transfer, or risk acceptance.

Step 3: Risk Management

Jones & Preston (2011); EMI (2006); Zerbo et al. (2020) have identified four basic approaches under the risks management decisions. Risk avoidance, risk mitigation, risk transfer and risk acceptance are the strategies used to manage the risk. Accordingly, risk can be avoid or eliminate by completely avoiding the activity or situation that poses a risk (Bello et al., 2021). In many cases, it may not be possible to completely eliminate risk, but it is often possible to reduce it. This involves taking steps to reduce the likelihood or severity of a potential risk. This could involve implementing safety procedures, installing safety equipment, or training employees to

handle potential risks. Moreover, risk can be transferred to another party or accepting the potential risk and planning for its impact. Finding the best decision depends not only on the circumstances but also on the values and priorities of the decision makers. However, reduction or mitigation is the best option to manage the disaster risk (Dickson et al., 2012).

Step 4: Risk Monitoring

Risk monitoring is a long term continuous process used to keep the implemented risk mitigation actions (Zerbo et al., 2020). The goal of risk monitoring is to identify any changes in the risk environment and to determine if new risks have emerged or if existing risks have become more or less significant. The use of risk monitoring tools and technologies, such as risk registers, dashboards, and automated alerts, can help to identify the risks and respond quickly to emerging threats (Deely et al., 2010). Effective risk monitoring involves continuous evaluation of risk factors, such as changes in economic conditions, industry trends, or regulatory requirements, and adjusting risk management strategies accordingly (Pinto, Nunes, & Ribeiro, 2011).

2.10 Disaster Risk Management in Urban Development Projects

According to Malalgoda and Amaratunga (2015b), coastal erosion, droughts, floods, landslides, cyclones and tsunami are the key disasters affect to the urban development projects in Sri Lanka. The severity level of a disaster depends on the degree of exposure to the population and its physical or economic assets (Dickson et al., 2012). Therefore, it is important to manage the disaster risks in urban development projects to achieve sustainability in the country. Figure 2.4 describes the disaster management process used for urban development projects.

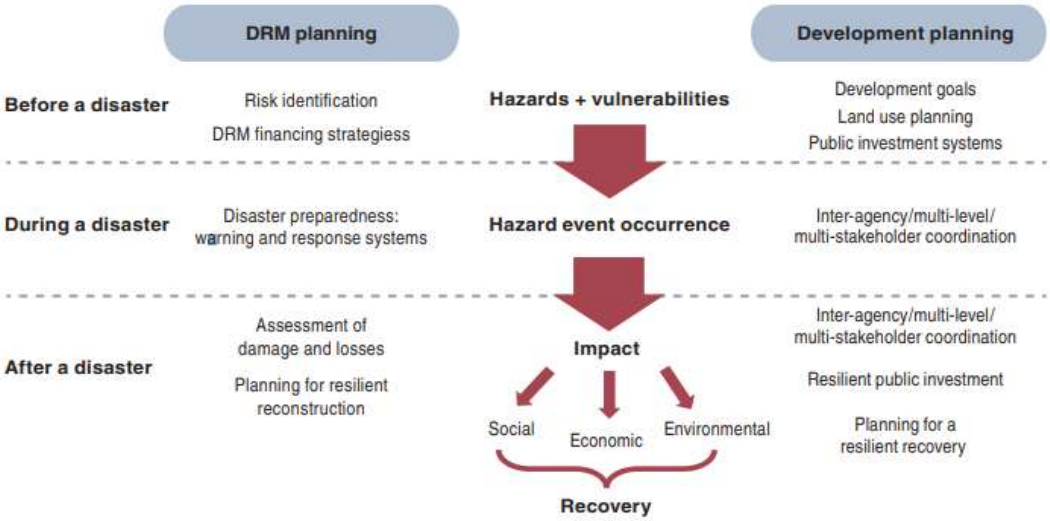
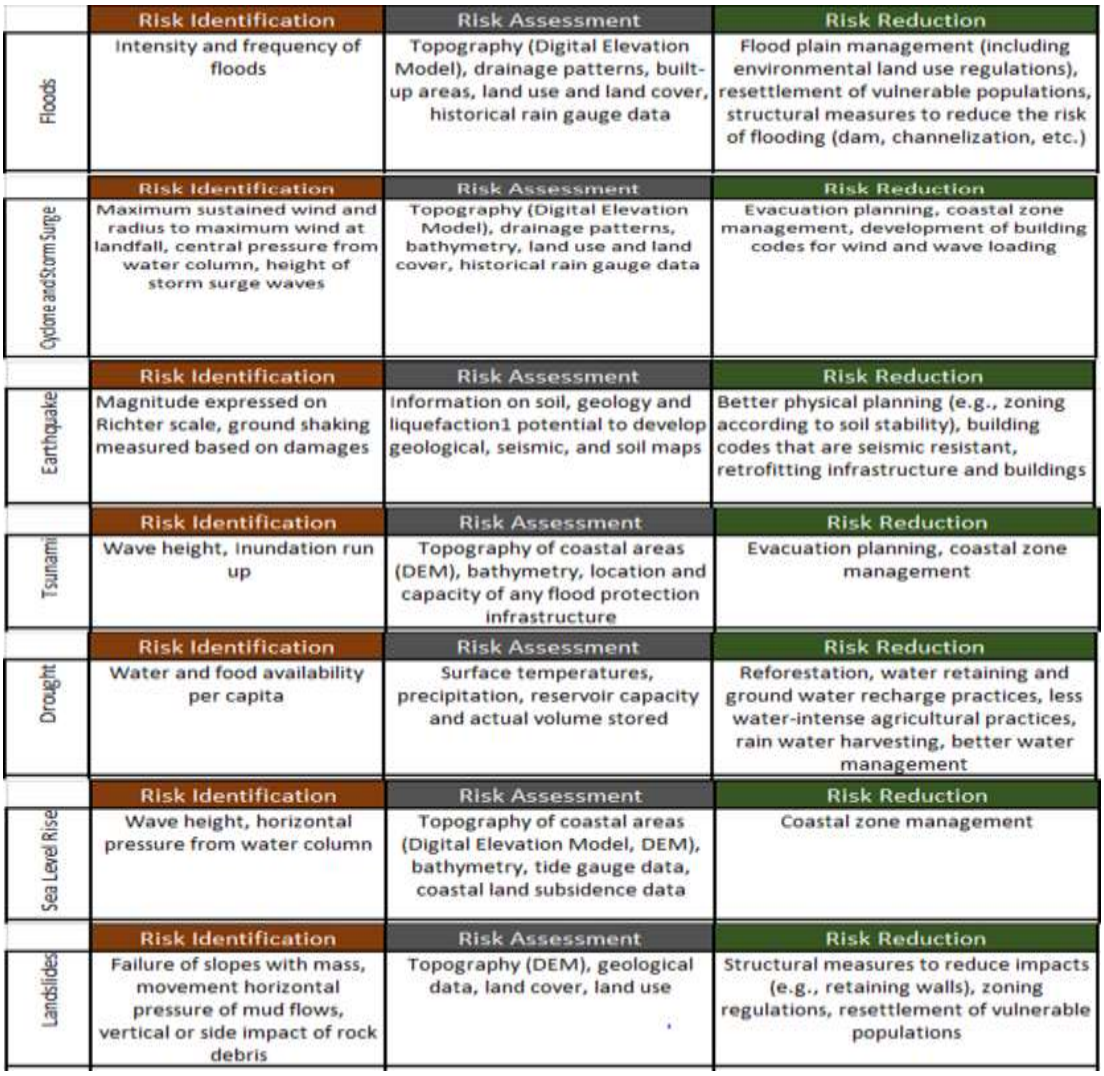


Figure 2.4: Disaster Management in Urban Development

(Source: Bello, Bustamante, & Pizarro, 2021)

Moreover Dickson et al. (2012) has explored that disaster risk reduction methods that can be used in an urban development projects to be resilient from natural hazards and climate change. Figure 2.5 shows the disaster risk identification, assessment and reduction methods used to manage the flood, storm surge, cyclone, earthquake, tsunami, drought, sea level rise, and landslides disasters.



	Risk Identification	Risk Assessment	Risk Reduction
Floods	Intensity and frequency of floods	Topography (Digital Elevation Model), drainage patterns, built-up areas, land use and land cover, historical rain gauge data	Flood plain management (including environmental land use regulations), resettlement of vulnerable populations, structural measures to reduce the risk of flooding (dam, channelization, etc.)
	Risk Identification	**Risk Assessment**	**Risk Reduction**
Cyclone and Storm Surge	Maximum sustained wind and radius to maximum wind at landfall, central pressure from water column, height of storm surge waves	Topography (Digital Elevation Model), drainage patterns, bathymetry, land use and land cover, historical rain gauge data	Evacuation planning, coastal zone management, development of building codes for wind and wave loading
	Risk Identification	**Risk Assessment**	**Risk Reduction**
Earthquake	Magnitude expressed on Richter scale, ground shaking measured based on damages	Information on soil, geology and liquefaction1 potential to develop geological, seismic, and soil maps	Better physical planning (e.g., zoning according to soil stability), building codes that are seismic resistant, retrofitting infrastructure and buildings
	Risk Identification	**Risk Assessment**	**Risk Reduction**
Tsunami	Wave height, Inundation run up	Topography of coastal areas (DEM), bathymetry, location and capacity of any flood protection infrastructure	Evacuation planning, coastal zone management
	Risk Identification	**Risk Assessment**	**Risk Reduction**
Drought	Water and food availability per capita	Surface temperatures, precipitation, reservoir capacity and actual volume stored	Reforestation, water retaining and ground water recharge practices, less water-intense agricultural practices, rain water harvesting, better water management
	Risk Identification	**Risk Assessment**	**Risk Reduction**
Sea Level Rise	Wave height, horizontal pressure from water column	Topography of coastal areas (Digital Elevation Model, DEM), bathymetry, tide gauge data, coastal land subsidence data	Coastal zone management
	Risk Identification	**Risk Assessment**	**Risk Reduction**
Landslides	Failure of slopes with mass, movement horizontal pressure of mud flows, vertical or side impact of rock debris	Topography (DEM), geological data, land cover, land use	Structural measures to reduce impacts (e.g., retaining walls), zoning regulations, resettlement of vulnerable populations

Figure 2.5: Disaster Risk Management - Example

Sources: Dickson et al.(2012; Institute of Policy Studies, (2016); UNDP (2010); Tran et al.(2009); Asian Disaster Preparedness Center(2007)

As per Figure 2.5 there are different disaster risks identification, assessment and reduction techniques used to manage the disaster in urban development projects, and it further highlights the topography of the environment as a key factor to be considered for the risk assessment.

2.11 Drawbacks of Risk Management in Urban Development Projects

In the present, urban development planning is considered as a challenging task due to the rapid urbanisation and climate change (Zoysa, 2021). By mainstreaming the risk management activities and development activities, people live in urban areas can respond the disaster effectively, but, developing countries has given less priority to disaster vulnerability and climate change conditions during the developments (The World Bank, 2020).

Lack of knowledge and experience among urban developers on the existing risk generating sources and potential impacts to the environment is one of the key barriers for effective risk management (Dickson et al., 2012). Moreover, unavailability of the structured risk assessment approach to assess the risks related to the urban development projects is also a greatest issue in disaster management process. Therefore, proper guidance and attention should be given to manage the risks in urban settlements.

Urban developers have limited resources to aware about urban growth. As such, developers not highly considered about disasters and climate change risk when they are planning development projects. Therefore, enough technical and financial resources needed to assess and respond to disasters more effectively (Nguyen & Nguyen, 2018).

Urban developers required to learn about best practices used by different urban development projects to manage the risks, but developers do not have a proper information sharing method to exchange the relevant information (Roslan et al., 2021). Therefore, it is a must needed strategy to be implemented in future development and urban development sector should be focus to develop a collaborative information sharing process.

2.12 Risk Sensitive Urban Development

Urbanisation and climate change are directly and indirectly caused to generate natural disasters within urban development projects (Hossain et al., 2017). Therefore, creating a practical plan for managing the risks is the best solution to achieve the short term and long term disaster risk reduction strategies. (Dickson et al., 2012). Under that, urban developers and policy makers have developed the strategies by considering both development plans and climate change risks (Zoysa, 2021).

2.12.1 Definition of risk sensitive urban development

The definitions for risk sensitive urban development gathered from several sources are presented in Table 2.9.

Table 2.9: Definitions for Risk Sensitive Urban Development

Definition	Literature Sources
Risk-sensitive urban development is an integration of disaster risk reduction methods and development planning across all sectors of development that help to protect gains made towards achieving development goals.	(United Nations Economic and Social Council, 2015)
Risk-sensitive urban development is an innovative planning approach that can transform the way cities are built in order to face the uncertainties that arise from climate-induced disaster risks.	(Roslan et al., 2021)
Risk-sensitive urban development is an approach used to reduce accumulated risk when planning new developments.	(Leck et al., 2021)
The risk sensitive development is an approach, which encourage communities to build their developments to effectively manage the disaster risks and to become resilient.	(Saja et al., 2020a)
Risk sensitive urban development is considered as the cornerstone to build the resilience of nations and communities and achieve sustainability.	(UNISDR, 2014)

Sources: (United Nations Economic and Social Council (2015); Roslan et al. (2021); García-Mayor et al. (2021); Saja, Sahid, & Sutharshanan (2020a); UNISDR (2014)

By reviewing the definitions presented in Table 2.9, the risk sensitive urban development in this research has been defined as "an approach that integrates the process of disaster risk reduction and urban development to enable such development to effectively manage the disaster risks and to become resilient".

2.12.2 State of the art in risk sensitive urban development

In order to identify the state of the art in risk sensitive urban development, a systematic literature review was conducted using PRISMA method. Accordingly, Table 2.10 presents the approaches identified under the risk sensitive urban development.

Table 2.10: State of the Art in Risk sensitive Urban Development

Approach	Description	Literature Sources	Frequency	
			Nr	%
A1 - 3D Ecological Foot Print Model	3D Ecological footprint model has been developed to measure natural capital utilisation pattern which directly affects the urban environment. The model has three dimensions such as Ecological Carrying Capacity Intensity (EC intensity), Ecological footprint depth (EF depth) and Partial Least Squares (PLS) model. EC intensity was calculated to optimize the accounting of ecological carrying capacity (EC) and EF depth and EC intensity were quantitatively investigated and influencing factors were further explored based on a partial least squares (PLS) model. The findings of the above mentioned 3D model could provide guidance for risk sensitive urban development.	[2], [11], [12], [15], [18], [29], [34], [38], [47], [53]	10	19%
A2 - Malmquist - Luenberger (M-L) index	M-L index has been developed to analyse the changes in efficiency and the impact of technological innovation on risk sensitive urban development, and give policy recommendations to promote risk sensitive urban development.	[7], [17], [25], [44]	4	7%
A3- Mobile Mapping System (MMS) with 3D GIS Model	3D Geographical Information System (GIS) support urban planners and consumers to improve their spatial perception and awareness of urban areas. In the long term, it is hoped that this work will help the public or increase community-engaged participation for additional urban planning. Currently, Mobile Mapping Systems (MMS) with 3D GIS are used to create precise and detailed 3D city	[1], [3], [4], [5], [14], [19], [22], [41], [42], [46], [48], [50]	12	22%

	modelling, which gives essential information for planning the urban development projects. 3D city modelling allows urban planners and the public to understand the areas of interest in the urban design-context in a spatial, timely, and virtual manner. Various approaches for building textures for a 3D model exist, e.g., 3D city modelling can use airborne images, airborne light detection and ranging (LiDAR), ground-based or vehicle-borne sensing techniques, and combinations of these.			
A4 - Environmentally Sensitive Areas Index (ESAI)	Environmentally Sensitive Areas Index (ESAI) was developed to identify areas vulnerable to the threat of desertification. Variables and thematic indicators such as climate, soil quality, land use, amount of plant cover and management are included in the ESAI.	[2], [4], [9], [11], [20], [22], [30], [41], [46], [53]	10	19%
A5 - Storm surge disaster loss (SSDL)	Storm surge is one of the most severe marine disasters in the world and it is affecting the whole coastal area. Therefore, to prevent from storm surge disasters, estimating the storm surge disaster loss (SSDL) is very useful and it will support the risk sensitive urban development process. When estimating the storm surge loss, hazards of the project, disaster causing factors, the vulnerability and resilience of disaster bearing bodies are considered. Accordingly, when planning an urban development project, the estimation of	[50], [54]	2	4%

	SSDL is beneficial as it provides a basis to make the decisions about project.			
A6 - Marine Ecological Red Line (MERL)	Coastal marine ecosystems are sensitive to anthropogenic stressors and environmental change. The Chinese Government proposed an ecosystem-based marine spatial planning scheme called the "Marine Ecological Red Line" (MERL), which aimed at protecting ecologically sensitive areas. The assessment and mapping of ecosystem sensitivity provide important tools for regional MERL and setting conservation priorities. This model provides details to decide which area is suitable to develop an urban development project. It gives an operational approach to provide relevant scientific knowledge on the process of ecosystem-based marine spatial planning, and facilitates policy-making decisions in marine management with risk sensitive urban development.	[19], [24], [33], [36], [39], [41], [54]	7	13%
A7- GRaBS assessment tool	GRaBS has been developed as a collaborative, innovative, cost effective and a user friendly assessment tool to highlight the climate change risks and vulnerabilities in urban areas in order to aid the strategic planning and delivery of climate change adaptation responses.	[21], [26]	2	4%
A8 - Sustainable design	Urban designs that consider regional climatic conditions are one of the most important approaches in risk sensitive urban development. The design of the urban development should be developed by considering the climatic conditions of the area.	[10], [28], [33], [36], [41], [45]	6	11%

A9 - Standardised Precipitation-Evapotranspiration Index (SPEI)	This index is explained about the impact of climate change on Land degradation and desertification (LDD) by detecting the temporal oscillations in drought in the context of climate change, and it is therefore a reliable climate parameter for this method. At present, LDD is one of the greatest environmental challenges caused by climate change resulting mainly from anthropogenic activities. SPEI is pointing to a link between not only environmental sensitive areas and climate change, but also the impact of other factors, such as vegetation, topography and soil. Therefore, the details received from SPEI is valuable for the risk sensitive urban development.	[32]	1	2%
A10 - Early warning system	In order to face the uncertainties that arise from climate-induced disaster risks there is an urgent need of early warnings system. Through this system, people can be aware about the risk and prevent the risk before it leads to a disaster. As such, early warning system is a beneficial approach, for the risk sensitive urban development.	[8], [41], [43]	3	6%
A11 - Smart urban plans	Smart urban planning is an innovative method of risk sensitive urban development since it is planned to develop all the urban facilities by considering the environmental aspects.	[3], [12], [23], [39], [48]	5	9%
A12 – DPSIR Model	Driving-Pressure-State-Influence-Response (DPSIR) model is based on environmental early warning system which combines three aspects such as ecology, resources, and environment. DPSIR model also includes human activities, stress, and environmental state, impacts on ecosystems, human	[16], [19], [27], [31], [32], [43]	6	11%

		health, and political responses. First, the DPSIR model covers important elements of economy, society, resources, and environment, which can clearly and simply reflect the relationship between the environment and other factors, thus it can provide a scientific theoretical basis for policymakers. Secondly, it not only indicates the influence of society, economic development, and human behaviour on the consumption of resources and ecological environment, but also shows the feedback of human behaviour and its final lead to the state of resources and environment, which makes the whole system a cycle. Thirdly, it provides a basic framework for the construction of the environmental index system which is suitable for early warnings and the assessment of the environment. Lastly, its evaluation process is relatively easy to operate and use, which brings convenience to scientific researchers. Therefore, when countries go for a risk sensitive urban development this model will be very useful in minimising the risk of urban areas.			
A13 - Drone Technology		Drone technology is one of the artificial intelligence method used to forecast disasters and provide support for the risk identification and assessment process.	[3], [37]	2	4%
A14 - Climate change risk assessment tools		Assessment of climate change risks and vulnerability is essential in order to inform and implement appropriate adaptation strategies. Assessment of climate change risk helps to improve the resilience of urban areas since, it is provided information to develop strategies to reduce future risks	[11], [12], [15], [16], [26], [28], [33], [34], [35], [38], [50], [51]	12	22%

	associated with climate change impacts. There are several climate change risk assessment tools such as decision making frameworks, portals or platforms and screening models. These tools are used to manipulate and visualise the general risk or impact of the climate change.			
A15 - Community engagement	Community views have been identified as one of the major approaches that can be used when planning an urban development project. Community is the party who is facing the risk of urban development projects and their views and suggestions will be very useful to reduce such risks to create a risk sensitive urban development project.	[2], [6], [28], [40], [41]	5	9%
A16 - Remote Sensing Techniques	Remote sensing technology is used to calculate the Salinized Land Degradation Index (SDI). By using this remote sensing technology, SDI calculates the Salinization Index (SI), Normalized Difference Vegetation Index (NDVI) and Land Surface Soil Moisture Index (LSM) at once. The combination of the aforementioned indicators can provide a comprehensive understanding of land degradation in salinized areas for the reference of regional land management.	[3], [20], [49], [32], [50], [52]	6	11%
A17 - Robotics Technology	Robots have used to travel high risk disaster zones to inspect the conditions of the area. It provides the details, photos, videos, and other data about the disaster zones to predict outcomes of previously unknown circumstances.	[3]	1	2%

A18 – Accident Hot Spot Analysis	Under this analysis, it identifies the accident-prone areas and analysing the accident pattern. Through this analysis, it helps to predict the pattern of accidents and urban developers can plan the urban developments while assisting to prevent and reduce accidents.	[3], [5]	2	4%
A19 – BIM based coordination support system	Building information modelling (BIM) used in the architecture, engineering, and construction (AEC) industries has changed the way emergency responses. It is a digital representation of all of the physical and functional characteristics of a building throughout its entire lifecycle. BIM based coordination system can coordinate the people involved to the projects successfully.	[13], [50]	2	4%
A20 – MEDALUS model	Mediterranean Desertification and Land Use (MEDALUS) model is one of the most widely used approaches to assess desertification risk in a development. This MEDALUS model mainly focuses five main indicators including soil, groundwater, vegetation cover, climate, and erosion were selected for estimating the environmental sensitivity to desertification.	[4], [32], [41], [42]	4	7%

Literature Sources – 54: [1]-(Abdellatif et al., 2021), [2]- (Abeje et al., 2019), [3]- (Abid et al., 2021), [4]- (Afzali, Khanamani, Maskooni, & Berndtsson, 2021), [5]- (Ahmad, Hossain, & Hossain, 2020), [6]- (Archer, 2016), [7]- (C. Chen, Lan, Gao, & Sun, 2018), [8]- (G. Chen, Li, Peng, Karamian, & Tang, 2019),[9]- (H. S. Chen, 2017), [10]- (Davey, Dunstall, & Halgamuge, 2017), [11]- (Ding, Zhou, Zhong, & Tang, 2019), [12]- (Dushkova & Haase, 2020), [13]- (Feng, Wang, Fan, & Hu, 2021), [14]- (Geekiyanage, Fernando, & Keraminiyage, 2021), [15]- (Golebieski, 2019), [16]- (He, Zhou, Ma, & Wang, 2019), [17]- (Hong, Xie, Liao, Tu, & Yang, 2017), [18]- (J. Hu, Huang, & Du, 2021), [19]- (W. Hu et al., 2019), [20]- (Hysa & Baskaya, 2018), [21]- (Kazmierczak & Handley, 2018), [22]- (Kilicoglu, 2022), [23]- (Kramer, Frese, & Kuijper, 2019), [24]- (Lee, 2018), [25]- (D. Li & Wu, 2018), [26]- (Lindley, 2009), [27]- (K. Liu, Xie, & Zhou, 2021), [28]- (C Malalgoda & Amaratunga, 2012), [29]- (Mesquita, Xavier, Klein, & Matos, 2017), [30]- (Nickayin et al., 2021), [31]- (Ozgul & Dindaroglu,

2021), [32]- (Perovic et al., 2021), [33]- (Petrea et al., 2021), [34]- (Raza, 2018), [35]- (Savini, 2017), [36]- (Schoonees et al., 2019), [37]- (Srivastava, Scott, & Rosier, 2022), [38]- (Stajkowski, Laleva, Farghaly, Bonakdari, & Gharabaghi, 2021), [39]- (Su, Fan, & Fu, 2020), [40]- (Thoresen, 2017), [41]- (Trenouth et al., 2018), [42]- (Uzuner & Dengiz, 2020), [43]- (W. Wang, Sun, & Wu, 2018), [44]- (Y. Wang, Yuan, Yan, & Zhang, 2020), [45]- (Watanabe et al., 2017), [46]- (Wei, Li, Xie, Zhou, & Guo, 2020), [47]- (Y. Yan, Zhang, Sharma, & Al-Amri, 2021), [48]- (B. Yang, 2019), [49]- (Y. Yang et al., 2022), [50]- (Y. F. Yang et al., 2021), [51]- (Yoon et al., 2017), [52]- (Yu et al., 2021), [53]- (Yuan, Zhu, Yang, & Xie, 2019), [54]- (Zhang et al., 2022)

While conducting the systematic literature review, state of the art in risk sensitive urban development approaches shown in Table 2.10 have been ranked based on the frequency of the approaches referred in the literature sources. Accordingly the range of frequency falls between 1% to 12%, where the approaches that has a frequency range of more than and equal to 10% are considered as highly referred risk sensitive urban development approaches, the approaches that has a frequency range between more than and equal to 5% and less than 10% are considered as moderately referred risk sensitive urban development approaches, and the approaches that has a frequency range of less than to 5% is considered as limitedly referred risk sensitive urban development approaches. The analysis is shown in Table 2.11.

Table 2.11: Literature Analysis of State of the Art in Risk Sensitive Urban Development

Approach	A1	A2	**A3**	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	**A14**	A15	A16	A17	A18	A19	A20
Number of Sources	10	4	**12**	10	2	7	2	6	1	3	5	6	2	**12**	5	6	1	2	2	4
Frequency of sources	19%	7%	**22%**	19%	4%	13%	4%	11%	2%	6%	9%	11%	4%	**22%**	9%	11%	2%	4%	4%	7%
Frequency of distribution	0.10	0.04	**0.12**	0.10	0.02	0.07	0.02	0.06	0.01	0.03	0.05	0.06	0.02	**0.12**	0.05	0.06	0.01	0.02	0.02	0.04

Color Legend

	Highly referred approaches
	Moderately referred approaches
	Limitedly referred approaches

According to Table 2.11, A1 - **3D Ecological Foot Print Model (10%)**, A3 - **Mobile Mapping System (MMS) with 3D GIS Model** (12%), A4 - Environmentally **Sensitive Areas Index (ESAI) (10%)** and A14 - **Climate change risk assessment tools** (12%) have been identified as key approaches that are highly referred in managing the disaster risks in urban development. Furthermore, Table 2.11 presents moderately referred six (6) risk sensitive urban development approaches; A6 - MERL (7%) , A8 - Sustainable design (6%) , A11 - Smart urban plans (5%), A12 – DPSIR model (6%), A15 – community engagement (5%) and A16 – remote sensing techniques (6%). Finally, further ten (10) risk sensitive urban development approaches such as A2, A5, A7, A9, A10, A13, A17, A18, A19 and A20 have been identified from the structured literature analysis. Moreover, the percentages derived under the frequency of sources that have used for systematic literature review have also confirmed that A1, A3, A4 and A14 approaches are highly referred in risk sensitive urban development.

When it comes to the Sri Lankan context, there are few approaches can be identified under the risk sensitive urban development and Table 2.12 summarises the findings.

Table 2.12: Risk Sensitive Urban Development Approaches in Sri Lanka

	Approach	**Sources**
A4	EASI	[1], [10]
A8	Sustainable design	[12], [13]
A11	Smart urban plans	[3], [13]
A15	Community engagement	[1], [2], [4], [5], [7], [8], [11]
A13	Drone technology	[13]
A10	Early warning system	[8], [9], [12], [13]
A14	Climate change risk assessment tools	[1], [3] , [6]
A16	Remote sensing techniques	[3], [13]

Sources: [1] - (Archer, 2016), [2] - (Chamindi Malalgoda, Amaratunga, & Haigh, 2016), [3] - (Cho, 2020) , [4] – (Geekiyanage, Fernando, & Keraminiyage, 2020), [5] - (Institute of Policy Studies, 2016), [6] - (Malalgoda & Amaratunga, 2012), [7] - (Malalgoda & Amaratunga, 2015a), [8] - (Malalgoda & Amaratunga, 2015b), [9] - (Mawilmada et al., 2016), [10] - (Rodrigo & Jayarathne, 2012), [11] - (Siriwardana, Jayasiri, & Hettiarachchi, 2018b), [12] - (Weerasinghe et al., 2018), [13] - (Zoysa, 2021)

According to Table 2.12, community engagement approach and early warning system are widely used approaches in Sri Lanka, while given less focus on drone technology approach.

2.12.3 Stakeholders involved in risk sensitive urban development

As per the definitions presented in Table 2.9, risk sensitive urban development is a combined approach that can be used by the stakeholders related to urban development and disaster risk management. asunder the stakeholders related to the risk sensitive urban development, urban developers, mayors, disaster managers, technical staff related to the urban development and disaster management were identified (Dickson et al., 2012). Apart from that, this collaborative effort requires a broader set of stakeholders to achieve risk sensitive urban development. According to Jayasena, Waidyasekara, Mallawarachchi, and Peiris (2021) the stakeholders related to Sri Lankan urban development has been presented in Figure 2.6.

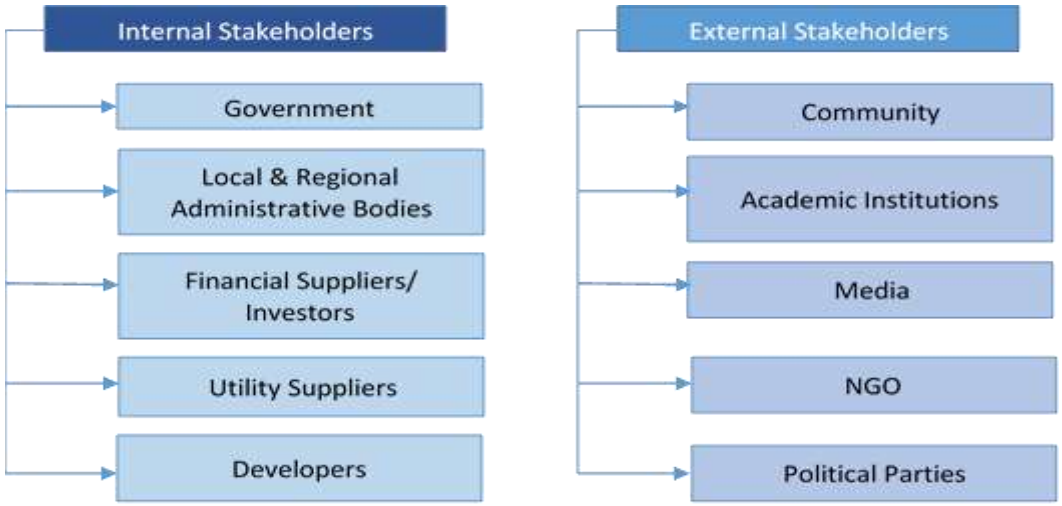


Figure 2.6: Stakeholders in Urban Development

Source: (Jayasena et al., 2021)

Moreover, Mohanty, Dubey, and Singh (2022) have identified the stakeholders related to the disaster risk management in Sri Lanka and shown in Figure 2.7.

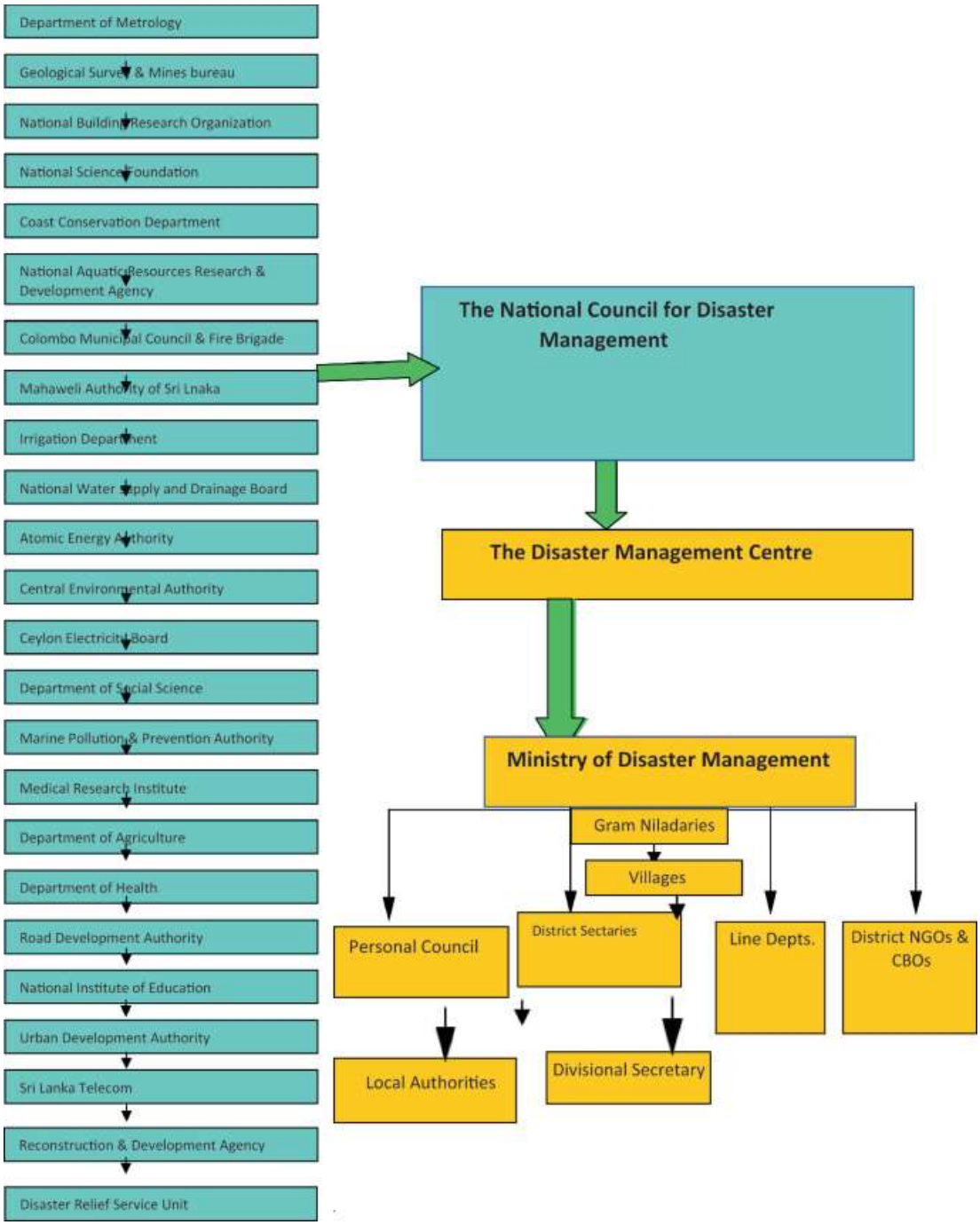


Figure 2.7: Stakeholders in Disaster Risk Management

Sources: Mohanty et al. (2022) ; Institute of Policy Studies (2016)

2.12.4 Benefits of risk sensitive urban development

Risk sensitive urban development improves the lives of people who are living in urbanised areas by providing safe access to basic infrastructure services, protecting environment and ensure resilience (Leck et al., 2021). It is highly needed educate urban developers, disaster managers and the public on sustainable urban development approaches because usual urban development projects will not be sustain in future due to the disasters (UN-HABITAT, 2013).

According to Fraser et al. (2017), risk sensitive urban development link the stakeholders involved in urban development and disaster management. Furthermore, risk sensitive urban development will empower government authorities and promote collaboration by empowering communities and a diverse range of stakeholders to demand good governance. It will facilitate to build public-private partnerships and bridge the rural and urban areas (Leck et al., 2018b).

Urban poverty is different from rural poverty and risk sensitive urban development specifically address the challenges of urban poverty (Fraser et al., 2017). Moreover, risk sensitive urban development connects with innovative infrastructure designs, advance technical facilities, and smart systems, which offer various benefits for improving access to basic services, increasing efficiency, and reducing pollution. Moreover, risk sensitive urban development guides developers for an effective spatial planning methods and it supports to face the future urban density (UN-HABITAT, 2013).

Urban development has caused for global warming, flooding, sea level rising, and extreme weather events. Therefore, urban planning should be ingrate with resilience planning and disaster risk reduction (Malalgoda & Amaratunga, 2015b). Since risk sensitive urban development approach concerns about the climate change impacts, urban areas have been developed to resist from the climate induces disasters as well.

2.13 Conceptual Framework

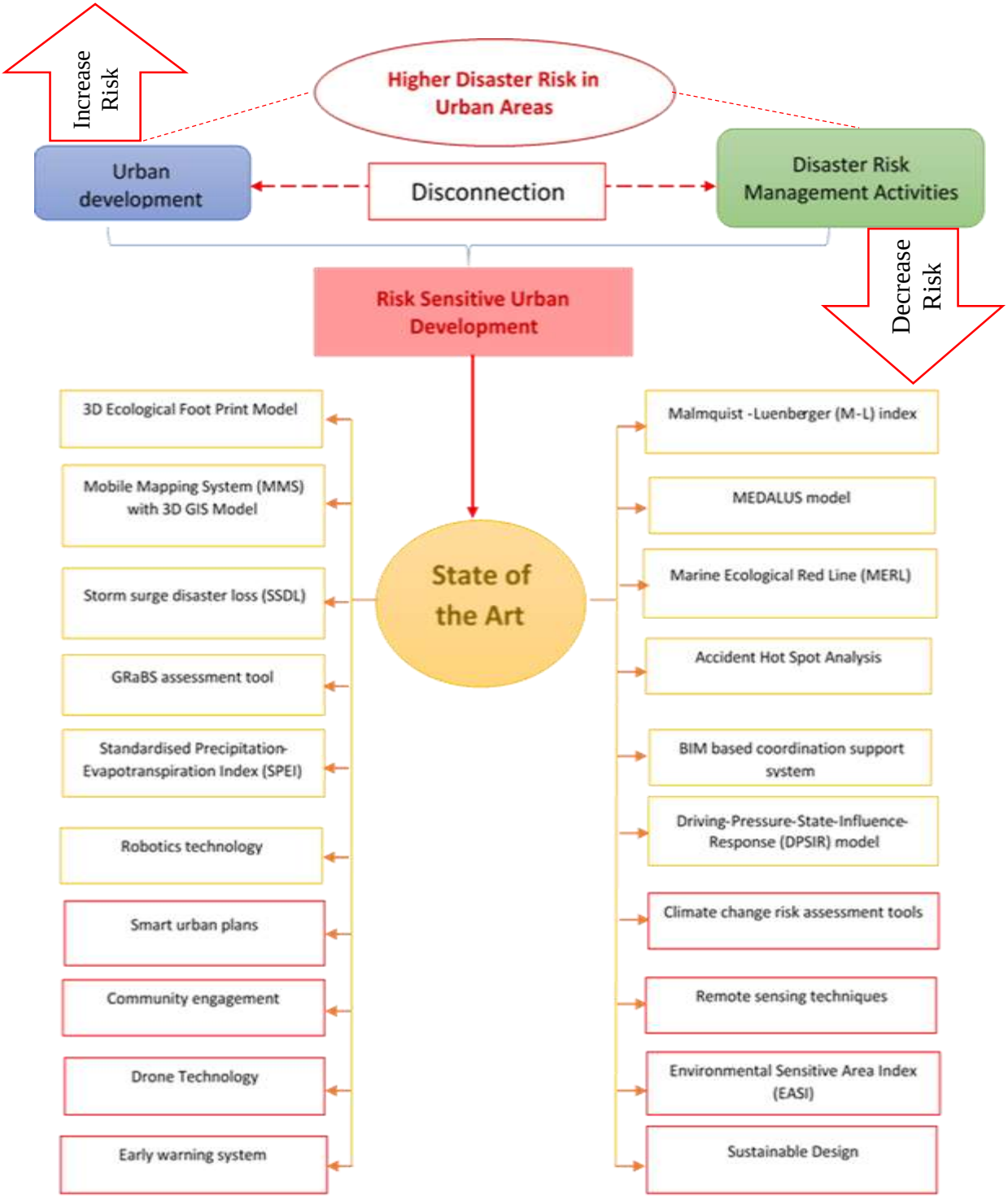


Figure 2.8: Conceptual Framework

Figure 2.8 presents the conceptual framework designed as per the findings derived from literature review. According to the top part of Figure 2.8, urban development has caused to increase the disaster risk, whereas disaster management try to reduce the disaster risk. The disconnection between the urban development activities and disaster management activities has led to generate a high disaster risk in urban areas. To avoid the disconnection and improve the collaboration between the urban development and disaster management, risk sensitive urban development is the best solution. Under that, there are different approaches have been identified under the state of the art in risk sensitive urban development. The identified risk sensitive urban development approaches are shown in the boxes outlined in red and orange colour. The orange colour outlined boxes represents the approaches used in Sri Lankan context. Accordingly, Figure 2.8 summarises the key literature findings and the conceptual framework has been further developed as per the framework in Figure 4.21.

2.14 Chapter Summary

The literature review chapter has been completed by doing narrative and systematic literature synthesis. Initially, an extensive traditional literature review was carried out to explore the disaster risks that are affected to urban projects, and disaster risk management process used for urban development projects in a global context. Under that, thirty types of disaster risks have been identified and risk management process was discussed. A systematic review was conducted to explore the state of the art in risk sensitive urban development and twenty approaches were discussed in this chapter. Finally, a conceptual framework has been developed to summarise the key findings derived from literature synthesis.

CHAPTER 3

3.0 RESEARCH METHODOLOGY

3.1 Introduction

Research is an analytical study which is considered as an essential part of professional practice (Kumar, 2019). According to the writer, the research methodology is the unique process or technique used to recognise, choose, evaluate and interpret information about a problem. Moreover, the research methodology is the master plan that can be used to accomplish the study objective and to effectively resolve the research question (Igwenagu, 2016). This section presents the research design and the research process pursued by the researcher to achieve the aim and objectives.

3.2 Research Methodological Design

Research design is the overall approach taken to conduct a research that establishes a clear and logical plan to address a predetermined research question through the data collection, data interpretation, data analysis, and data discussion. (Boru, 2018). The importance of research design emerges from its crucial role as a connector between the theories and justifications that guide the study and the empirical information gathered (Boru, 2018). Similarly, Gilbert and Churchill (1979) believe that research design provides direction for data collection and analysis in a specific study. The research process can be represented as an onion (Saunders, Lewis, & Thornhill, 2009). Research onion is consisted with several layers and approaches, which is shown in Figure 3.1. The following subsections explain the contents of the research onion: philosophies, approaches, strategies, choice, time horizons, and techniques and procedures.

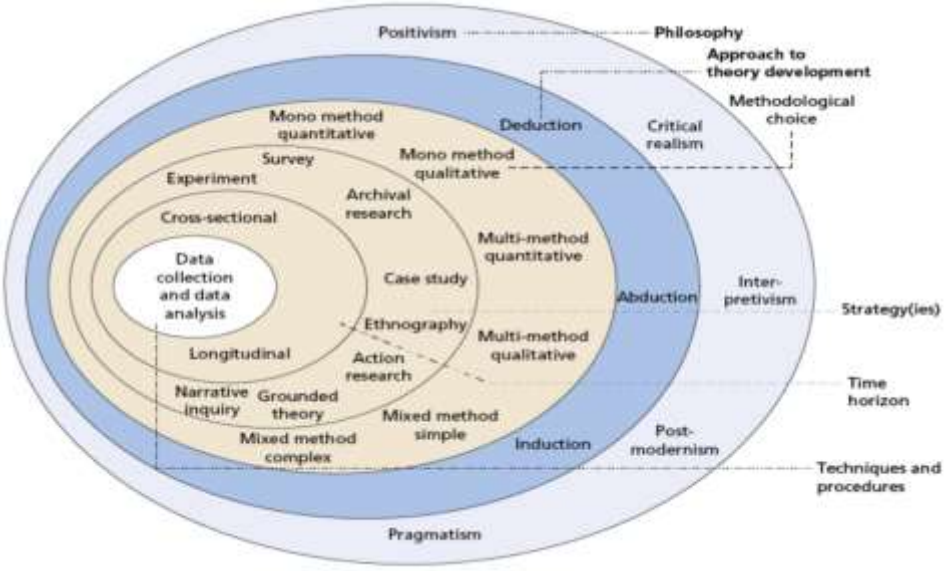


Figure 3.1: Research Onion

Source: (Saunders et al., 2009)

As per Figure 3.1, the research onion has six layers: philosophy, approach to theory development, methodological choice, strategies, data collection, and data analysis. In order to understand the next layer, the researcher must unravel each layer, beginning with the outermost layer. As a result, the next section presents the design of the research methodology for this study based on the layers of the research onion.

3.2.1 Research Philosophy

A research philosophy is the first and most significant layer of the research onion, which describes a set of beliefs or ideas about data collection, interpretation, and analysis (Saunders, Lewis, & Thornhill, 2015). Accordingly, the research philosophy influences the researcher's strategy with regard to the research plan or method he/she adopts for his/her research. One of the key factors influencing the selection of a particular philosophy is the researcher's particular viewpoint and opinion on the relationship between knowledge and the process by which it is developed (Saunders et al., 2009). There are various philosophies explained in the research onion such as ontology, epistemology and axiology (Al Zefeiti & Mohamad, 2015).

3.2.1.1 Ontology

The first branch is ontology, and it describes the "study of being", which human can learn about actual scenarios exist in the world (Moon & Blackman, 2017). According to Saunders, Lewis, and Thornhill (2019), ontology is based on the assumptions about the nature of reality.

3.2.1.2 Epistemology

Epistemology is the theory of knowledge that deals with how knowledge is gathered and where it comes from (Moon, Cvitanovic, Blackman, Scales, & Browne, 2021). In terms of research, the researchers' viewpoint and knowledge strongly influence to the data interpretation, thus philosophical position should be stated from the beginning. Saunders, Lewis, and Thornhill (2019) explained that this extreme encourages quantifiable observations with statistical analysis. Conversely, the other extreme relies upon the knowledge based on people and their opinions, where subjectivity is encouraged.

3.2.1.3 Axiology

Axiology includes a set of ethical guidelines and values that originate from the research process, such as inquiries into how we, as researchers, handle our own ethical principles and the ethical values of the research participants (Saunders et al., 2019). There are two main types under the axiology assumption such as value-laden and value-free. A value-free study, the choice of what and how to study is decided by objective criteria, while in value-laden research the choice is based upon human values and experiences.

According to the aforementioned assumptions, five major philosophical stances are introduced by Saunders et al. (2015) and Saunders et al. (2019) as positivism, critical realism, interpreitivism, postmodernism and pragmatism. Table 3.1 describes those philosophies.

Table 3.1: Research Philosophies

Philosophical Stance	Description
Positivism	Positivism is a theoretical situation associated with natural scientists that implies with observable social reality to generate law-like generalizations. This emphasises the positivist focus on scientific methods that generate pure data and facts without involving the human ideas. Positivism has the ontological assumption that reality is based on a pre-determined nature and structure, which is called realism. Furthermore, the positivist is connected with the epistemological belief that the features of reality must be assessed objectively rather than subjectively through sensation and reflection.
Critical realism	The primary aim of critical realism is to explain what researchers see and experience in terms of implicit fact the truth that define observable events. Critical realists concern reality as external and autonomous, but it is not directly achievable through observation and knowledge. Under the critical realism, researcher acknowledges bias by the world views, which leads to the value-laden approach in the axiological perspective
Interpreitivism	Interpreitivism elaborates that humans are distinct from physical phenomena because they generate meaning. According to interpreitivism, human beings cannot be examined in the similar way as physical phenomena, because researches related to social sciences different from natural science. Under the interpreitivism, researchers are considered as a part of what is researched, and their interpretations are contributed to the study.
Postmodernism	Postmodernism focuses on the importance of language and power dynamics in challenging conventional thinking and giving support to marginalized perspectives. They believe that any sense of order is provisional and based on nothing more than our language and its categories and classifications.
Pragmatism	Pragmatism is a research paradigm that resembles the characteristics in between two extremes; positivism and interpreitivism. It has been argued that there are strengths and weaknesses in both the two extremes and thus pragmatism is offered as the middle ground of two ends

As set out in the aim and objectives, the study expects to identify the different views of respondents regarding the risk sensitive urban development. As per Table 3.1, it can be deduced that since the study acknowledges that the reality is based upon social constructions, where the knowledge depends on the subjective measurements by

considering human values and experiences as a part of the study, interpreitivism is the most appropriate research philosophy for the study.

3.2.2 Research Approach

According to Saunders et al. (2009), research approach is the second layer in the research onion. Accordingly, the research approach has divided into three categories as deductive, inductive and abductive. The deductive approach uses literature to identify theories and ideas that will be tested using data by the researcher. In contrast, the inductive approach focuses to gather data and develop a theory based on data analysis results (Burney & Saleem, 2008). Abductive approach entails a combination of both deduction and induction approaches in which a researcher performs an empirical investigation to generate a new concept/theory or modify an existing theory, which is subsequently investigated the validity from the additional data collection process (Saunders et al., 2019). This study initially considered theoretical understanding of the subject and pre-developed approaches of risk sensitive urban development in order to develop a framework to support risk sensitive urban development in Sri Lanka. It also collected primary data to support the development and validation of the framework. Therefore, the abductive research approach was considered as most suited to this study since the study has combined the features of both inductive and deductive approaches.

3.2.3 Research Choice

The research choice is the third external layer of research onion involves basically selecting among qualitative, quantitative and mix methods. Research questions, objectives and topic of the research affect to the research method selection process (Al Zefeiti & Mohamad, 2015). Quantitative approach basically focuses factors such as sample size, data type, sampling techniques and selection, data collection procedures, data analysis plans (Grover, 2015). The quantitative approach would be more appropriate for the researches, which initiate the research question with ‘what’, ‘who’, ‘where’, ‘how much’ and ‘how many’ (Yin, 2014). According to Olds, Moskal, and Miller (2005), surveys, interviews, focus groups, conversational analysis, and

observation are examples of qualitative research methods used to collect and test textual data. Moreover, Cropley (2019) has explored that a qualitative method is used to investigate an issue related to respondents' work by gathering their opinions, attitudes, and perceptions. Moreover, respondents' life experiences are beneficial for the study. A mixed-approach uses both quantitative and qualitative methods to collect and analyse data in a particular study (Creswell, 2009). However, mixed approach is not a substitute for the qualitative or quantitative approaches. Having considered the three approaches which are described above, qualitative research approach was more suitable to this study, since this study investigates the views, attitudes and perceptions of urban developers and disaster managers when developing the framework.

3.2.4 Research Strategy

The research strategy represents the fourth layer of research onion, which provides direction for systematically conducting research and producing successful results (Dinnen, 2014). Saunders et al. (2009) have identified several research strategies such as experiment, survey, case study, ethnography, action research, grounded theory and archival research. Among these strategies, the survey research strategy will be adopted for this study, since it allows the researchers to utilise a variety of data collection methods including quantitative techniques such as questionnaires as well as qualitative techniques such as in-depth interviews and focus group discussions or both the techniques (Kabir, 2016). According to Yin (2014), case studies empirically investigates a contemporary phenomenon in depth to understand the difference between the real world context and the phenomenon. Qualitative survey strategy used to identify the human behaviours and preferences in a more rigorous manner using multiple valid and reliable instruments (Ponto, 2015). This research intends to develop a framework for risk sensitive urban development, where the primary data to be collected from a wider context covering both disaster management and urban development sectors. As such rather than an in-depth analysis on few cases, a comparatively shallow research on a wider context is necessary to achieve the objectives of the research. Therefore, a qualitative survey strategy has been adopted as the most suitable research strategy.

3.2.5 Time Horizon

This layer of the research onion explains the time frame of the research. According to Saunders et al. (2019), there are two types of time horizons namely; Longitudinal and Cross-sectional. Longitudinal studies are repeated over time, whereas cross sectional studies are limited to a specific time period. In general, surveys and case studies (short-term) adopt a cross-sectional time frame, while ethnography, action research, archival research and case study (long-term) adopt longitudinal time horizon (Saunders et al., 2015). Since this study investigates the disaster risk management process in Sri Lankan urban development projects and the user requirements to develop a framework to provide the guidance on risk sensitive urban development in the current context, it will not require chronological attributes of data, hence, cross-sectional time horizon was applied.

3.2.6 Techniques and Procedures

Sixth layer of the research onion explains the techniques and procedures used for data collection and analysis of the study. Accordingly, data collection techniques and data analysis techniques have been discussed in below.

3.2.6.1 Data Collection Techniques

Data can be gathered using a variety of methods, including literature reviews, observations, document reviews, questionnaires, interviews, and focus group discussions. According to Yin (2011) the most common qualitative data collection techniques are literature reviews, observations, interviews, document reviews, and focus group discussions. In order to achieve the objectives, this study used a variety of data collection techniques at various stages. Accordingly, Figure 3.2 shows the data collection techniques used in the study.

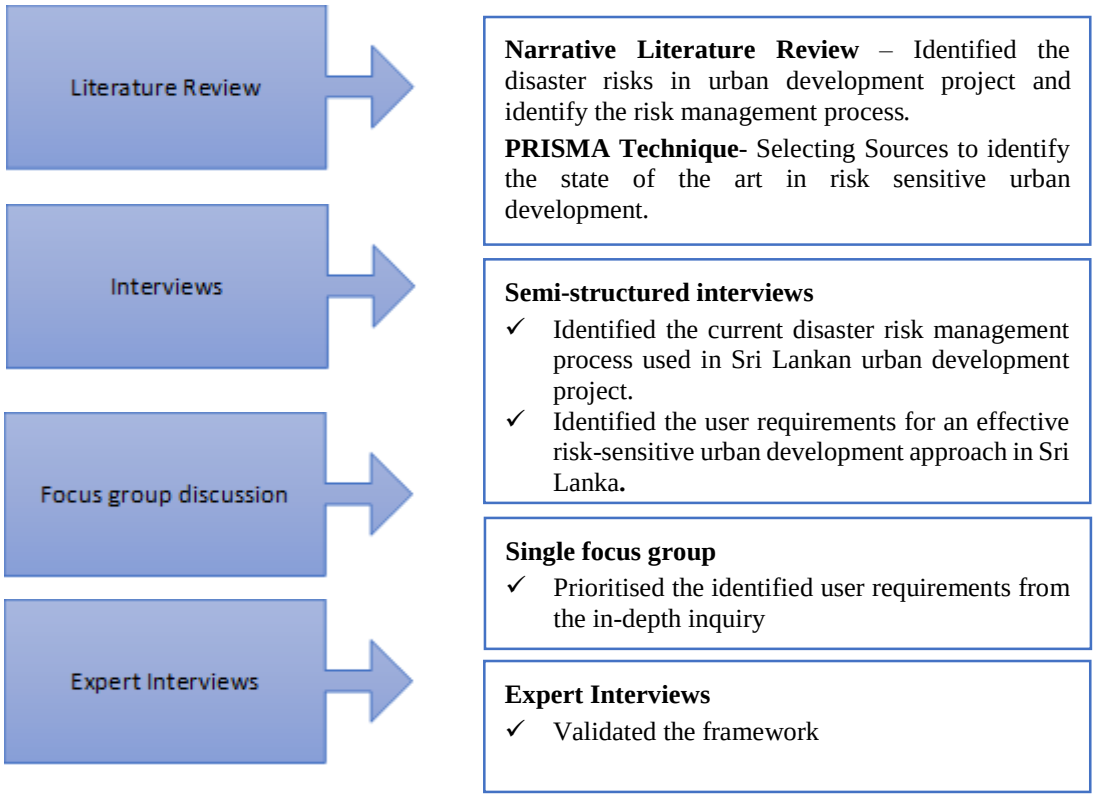


Figure 3.2: Data Collection Methods Used in the Study

As per Figure 3.2, data collection techniques can be further discussed as follows.

Literature Review

The aim of the literature review is to summarise and synthesise existing knowledge in a topic without creating any new insights (University of Edinburgh, 2021). The literature review helps the researchers even in turning the wheels of the research topic since it is based on prior information and provides the direction to be directed for success. Basically, there are two types of literature reviews such as traditional or narrative and systematic (Bruette & Fitzig, 2014). A traditional or narrative review presents a comprehensive literature background by refining research questions as well as developing conceptual and theoretical frameworks. A systematic review is a well-structured, more rigorous literature review that can be utilised to address the well-structured and specific research problems. The identification of the differences between these two major types is important while choosing the most relevant literature review type for a study. Thus, the comparison between these two major types has been presented in Table 3.2.

Table 3.2: Comparison between Traditional Review and Systematic Review

Factor	Narrative Literature Review	Systematic Literature Review
Main features	Review and discuss published articles, but do not describe the article selection process.	The research question, article selection criteria, data extraction and synthesis are well defined.
Uses/Applications	General discussions, evaluation of previous studies, and current knowledge gaps, Future research rationales, Consider new types of interventions that may be available.	Gather what is known about a topic and determine the source of that knowledge. Comprehensive report with explicit processes, allowing external organisations to examine rationale, assumptions, and methods.
Limitations	The assumptions and planning are rarely known. Preferences in sources selection and evaluation are unknown. Not repeatable.	The scope is constrained by the query, search terms, and selection criteria.

Source: (Ferrari, 2015)

According to Table 3.2, the traditional literature review is conducted without a specific methodological approach, and the findings are subjective, whereas the systematic review is conducted with an explicit methodological approach and evidence-based findings (Ferrari, 2015). Accordingly, the literature review of this study has been adopted both the aforementioned types in align with the aim and objectives into two stages. Initially, an extensive traditional literature review was carried out to explore the disaster risks related to an urban development projects and current disaster risk management process used for urban development projects in a global context. A systematic review was conducted based upon the publications of the last six years utilising two popular databases such as Scopus and Web of Science mainly to achieve the objective 1 which is to explore the state of the art in risk sensitive urban development. The methodological approach that was utilised for the systematic review is presented below.

Process of Systematic Literature Review

The systematic reviewing approach has gained popularity among different types of reviews due to its unique characteristics that cannot be observed in other traditional reviewing methods (South & Lorenc, 2020). Furthermore, the systematic review is a process that follows a well-structured methodology, which provides the reliability, validity, and adequacy of the selected standards. As a result, a systematic review was chosen for this study because it provides valid and reliable results from the literature with a high level of accuracy and efficiency, which is critical in evaluating several perspectives of different researchers about the state of the art in risk sensitive urban development. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method was used to conduct this study (Liberati et al., 2009).

- **Step 1: Specified Aim, Objective and Research Question**

Establishing a strong research question is a primary requirement to develop the search strategy, eligibility criteria, and study selection as per the PRISMA method (Eriksen & Frandsen, 2018 ; Liberati et al., 2009). Accordingly, the aim of carrying out a systematic review was to explore the "state of the art in risk sensitive urban development". The objectives for achieving this aim were developed as conducting a systematic literature review to identify the different approaches or tools or methods that can be used for risk sensitive urban development. PICO approach has been used to develop the research question and derived the search terms for the systematic review. The PICO approach guides researcher to formulate the research question and define the keywords for the literature survey from the terms included in the research question (Aslam & Emmanuel, 2010). Following the PICO approach, the first step was to construct a logic grid (Table 3.3) and conduct an initial search using the key terms in the grid. Alternative terms or synonyms for the identified concepts were then added by scanning the titles and abstracts of retrieved articles in this initial search to populate a comprehensive logic grid (Table 3.4). According to Taylor (2017) a comparison is not always required or appropriate depending on the type of research question. As such the Comparator (C) component was neglected in this study since there is no

comparator to compare with the intervention in the research question. Table 3.4 provides a comprehensive search strategy consisting of both keywords/free-text words and index terms. Accordingly, the index terms of the study were searched from the list of keywords offered by the initial literature search. As the final step in developing key terms for the search, search-field descriptors and wildcard characters were applied to the identified keywords and index terms in the logic grid (wildcards are indicated by the '*' sign in Table 3.4).

Table 3.3: Logic Grid for PICO Approach

Population	**Intervention**	**Comparator**	**Outcome**
Urban development	Risk sensitive urban development	-	State of the art

Table 3.4: Logic Grid with Identified Keywords Added

Population	**Intervention**	**Comparator**	**Outcome**
Urban development	Risk sensitive urban development		State of the art
	Hazard sensitive		Modern*
Urban*	Disaster sensitive		New*
Sustainab* development	Flood sensitive		
	Landslide sensitive		
Land development	Ecological sensitive	-	
Urban water management	Environment* sensitive		
	Vulnerab* sensitive		
	Urban* sensitive		

- **Step 2: Sources Selection**

Scopus and Web of Science databases were used to keep the quality of the study (Geekiyanage et al., 2020). Accordingly, both the databases provide a literature search within a broad range of international scientific journals, as well as within high-ranking conference proceedings. Furthermore, a Google search was also conducted to identify non-journal sources such as periodic reports issued by subject-related organisations. Finally, all the records generated from the above-mentioned databases were imported to the Mendeley software for screening and systematic analysis

- **Step 3: Develop Search Strategy**

Once all the search terms were collected and finalised, the final search strategy was developed. Initially, the key terms and synonyms in the logic grid were combined using Boolean operators: 'OR' to combine words/phrases within a column; 'AND' to combine words/phrases in different columns. Subsequently, the second search was undertaken across all the selected citation databases with the use of the developed search strategy as shown in Figure 3.3.

"**State of the art**" OR "modern*" OR "new*" AND "**risk sensitive**" OR "hazard sensitive" OR "disaster sensitive" OR "flood sensitive" OR "landslide sensitive" OR "ecological* sensitive" OR "environment* sensitive" OR "vulnerab* sensitive" OR "urban* sensitive" AND "**urban development**" OR urban* OR "sustainab* development" OR "land development" OR "urban water management

Figure 3.3: Search Strategy

- **Step 4: Eligibility Criteria Selection**

The search strategy was developed with relevant filters such as publication year, subject/research area, document type, and language (Refer Table 3.5).

Table 3.5: Filters Assigned for the Literature Search

Categories	Filters
Search Fields	Title, Abstract, Keywords
Publication Year	From 2017 to 2022
Document Type	Article, Proceedings paper
Language	English

- **Step 5: Study Selection and Data Extraction**

The title, abstract, keywords, authors' names and affiliations, journal name and year of publication, access type and source name of the identified records were exported to the Mendeley software. All the identified articles were subjected to title and abstract screening initially and identified as: relevant, irrelevant and unsure by a single reviewer. In this stage (1) articles not relating to risk sensitive urban development, (2) articles not contributing to identify the state of the art in risk sensitive urban development and (3) articles that were completely irrelevant to the research area were excluded. In the second screening process, the full texts of all the relevant articles were reviewed and the necessary data was extracted. As per this study, the extracted items imported to a separate folder in Mendeley software in order to elaborate the state of the art in risk sensitive urban development. Having conducted the search strategy on the above mentioned databases, 285 articles were identified and 6 duplicates were removed. From the 279 articles 136 articles were removed by referring the title of the paper, 37 articles were removed by referring the abstract and 58 articles were removed after reading the full research paper. After removing the non-suitable articles, 48 articles were selected from the main databases and 6 articles were added from the Google search. Finally, in depth literature synthesis was carried out on the 54 articles that were selected for analysis. The following section elaborates the state of art in risk sensitive urban development based on the systematic review of literature. The selection of the articles procedure depicts in Figure 3.4.

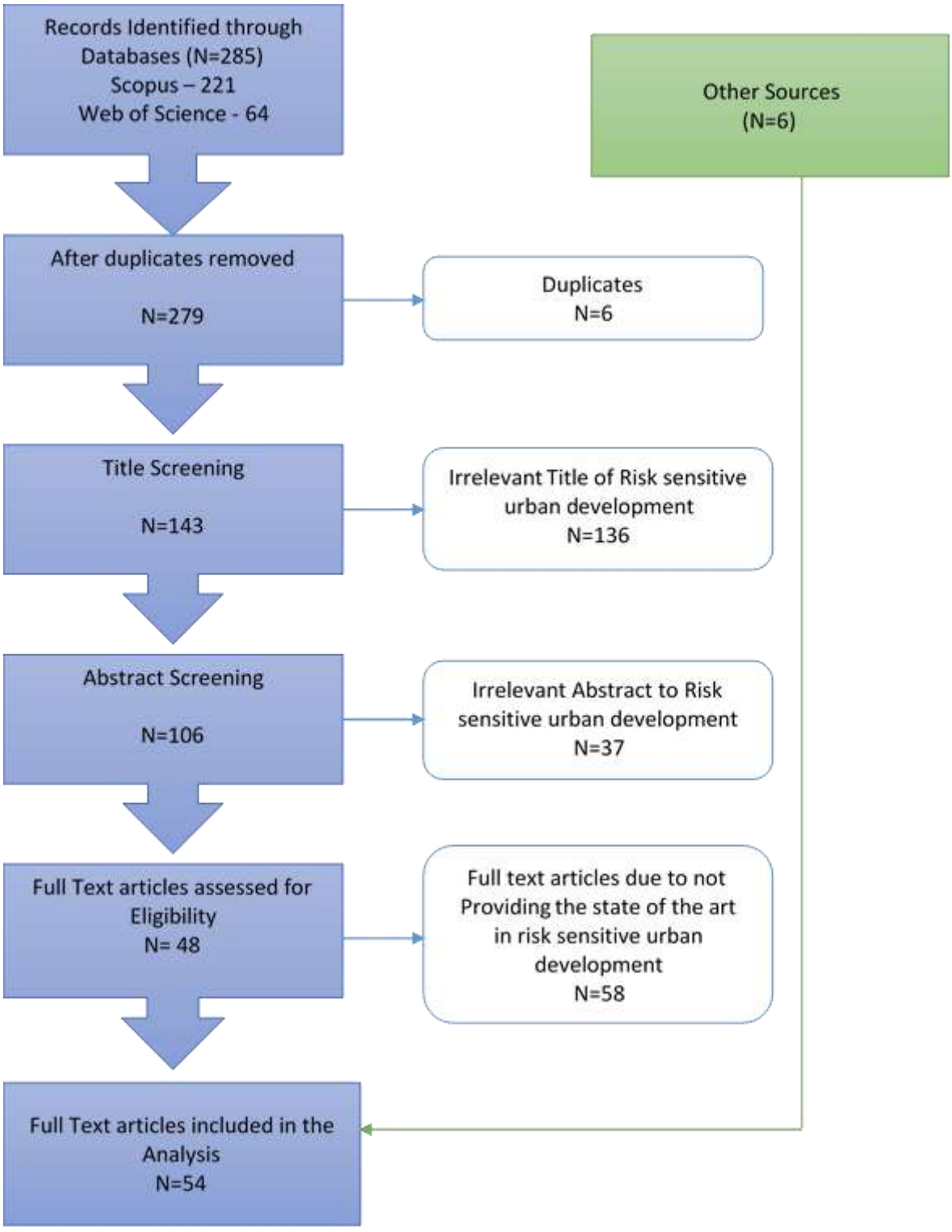


Figure 3.4: Article Screening Process

Interviews

Interviews have been identified as the commonly used method of data collection to carry out an in-depth inquiry regarding a phenomenon and they mainly fall within the qualitative research (Hammarberg, Kirkman, & de Lacey, 2016). Interviews can be three types namely structured, semi-structured and unstructured (Yin, 2011). Structured interviews based on the standard set of questions, which are kept consistent from interview to interview. Unstructured interviews have been used when the researcher has enough understanding about his/her research topic to conduct the discussion with the informant. However, this study needs to explore the current disaster management process used in Sri Lankan urban development projects and capture the user's requirement for effective risk sensitive urban development in Sri Lanka. Under the semi structured interviews, it follows a guideline, but is able to change and add more queries within the conversation when researcher feels this is appropriate. Hence, semi-structured interviews were adopted to eliminate the flows identified with the structured and unstructured questions. Accordingly, twenty (20) semi structured interviews were conducted with the stakeholders in urban development and disaster management sectors. The interview guideline has been prepared to explore the current process used to identify, assess and manage disaster risks in urban development projects in Sri Lanka (objective 2) and to capture the user requirements for an effective risk-sensitive urban development approach in Sri Lanka (objective 3).

Focus Group Discussion

Focus group discussion is a popular qualitative data collection method which can be used to solve social issues (Nyumba, Wilson, Derrick, & Mukherjee, 2018). Data have been collected from a purposefully selected group of people without considering the statistical represent. Further, Tonkiss (2004) appreciated the ability of this method to explore the attitudes, meanings and definitions through the participants' own terms as a group. Among the multiple instances that the focus groups can be adopted in a particular study, Prasad (2017) emphasised the suitability of the method to clarify, extend, qualify or challenge the data collected through other methods. Accordingly, in

this study, focus group discussion was adopted allowing the participants of the group to prioritise the identified user requirements. Since the user requirements were analysed using ‘User Stories’ technique, the participants were requested to prioritise the user stories as per the MoSCoW method (Must-have, Should-have, Could-have and Won’t-have). In terms of the group size, since Peek and Fothergill (2009) explored through their experience that a number of participants between 3-12 is ideal for a focus group rather than larger groups, three participants were selected through purposive sampling. In order to address both the areas of disaster management and urban development, three participants with knowledge of the urban development and disaster management were chosen. Online zoom platform was used to conduct the focus group session.

Expert Interviews

Under the expert interviews, interviewee has been selected by considering his/her area of knowledge and experiences. They can be done formally or informally and be done over the phone or by email (Nyakuwanika, Poll, & Vander, 2021). Expert interviews provide specific information about a specific study area. As such 2 experts, one each from urban development and disaster management sectors, were identified to perform the framework validation.

3.2.6.2 Data Analysis Techniques

In general, data analysis is highly dependent on the researcher's empirical thinking and interpretation style (Maher, Hadifield, Hutchings, & Eyto, 2018). Data analysis is the process of compressing a large amount of collected data in order to make meaningful interpretations (Cropley, 2019). There are multiple data analysis methods for qualitative studies such as content analysis, narrative analysis, discourse analysis, thematic analysis etc. Among them, content analysis was adopted to this study for analysing the data gathered through interviews and focus group discussions.

Qualitative Content Analysis

The content analysis process includes the reduction of data into a coding system that defines the phenomenon by developing categories, conceptual systems and conceptual maps that help to interpret the data in a meaningful manner (Baxter, 2020). This type of analysis is more useful to analyse the large amounts of verbal data that are collected through in-depth interviews or focus groups.

User Requirement Analysis

The user requirement is a specific feature or function that the system user requires. The final result of a user requirement analysis can be thought of as the overall picture of the system from the users' point of view (Maguire & Bevan, 2002). The user story format has grown in popularity as a means of expressing user requirements because it focuses on the user's perspective, who is impacted by the system, defines the requirements in simple, understandable language, and aids in clarifying the true reason for the requirement (Rehkopf, 2022). The user story mapping methodology is used in several steps to analyse user requirements. The process pertaining to this study is discussed below, along with appropriate justifications.

- **Step 1- Establishing the vision**

Initially, the purpose of creating a user story map should be established. This step identifies the system description that needs to be developed. As per this study, the vision is to “develop a framework for supporting risk-sensitive urban development in Sri Lanka”.

- **Step 2- Identifying the users of the system**

At the second step, the users of the particular system are identified. As per the planned framework of this study, the following users’ levels were interviewed.

- Officers in the disaster management and urban development sectors
- Disaster management officers and urban development officers at provincial and district level

- Disaster management and urban development officers at divisional level
- Grama niladari
- Community members

➢ **Step 3- Build the backbone**

The top row of the user story map is called as a backbone. It specifies the core capabilities that the system must have (Patton, 2014). User interviews are used to determine the backbone. The user is asked to describe their process from start to finish, including all high-level activities that they will expect from this framework (Refer Figure 3.5). The backbone anticipates a smooth user journey through the system in the absence of detailed information.

Figure 3.5: Backbone Development

➢ **Step 4 - Divide the tasks into user stories**

At this point, the identified activities are divided into several user stories (Tasks). Users are asked to explain their needs (describe more specific tasks) in the form of user stories under relevant activities (Refer Figure 3.6). In this study, users were asked to explain their roles and responsibilities in relation to the risk sensitive urban development. Following that, a final user story map was created by combining all of the users' user story maps, which will be directed to the prioritisation process. At this stage, user stories with similar meanings will be combined into a single user story (Patton, 2014). As a result, by eliminating repetitions of user requirements, the user story map has been well structured.

Figure 3.6: User story map

- **Step 5- Prioritization of user stories**

Following the completion of interviews with each user, there may be a large number of user stories for the overall system. However, it is not feasible to integrate all of the user stories into a single system in the first release. As a result, in this step, user stories are prioritized by estimating their value from the perspective of the users and selecting the most valuable user stories to be included in the framework. Prioritization methods in use include the MoSCoW method, the complexity matrix, the walking skeleton method, and others. Among these prioritisation methods, the MoSCoW method is the most commonly used due to its simplicity and user-friendliness, which allows users to easily prioritize user stories. The term MoSCoW stands for Must-haves, Should-haves, Could-haves and Won't-haves as described below.

- **M**- Must have - Describe the requirements that must be included in the final solution.
- **S**-Should have - Represent the high priority item that should be included in the solution if it is possible
- **C**-Could have - Describe the requirements which are desirable, but not necessary.
- **W**- Won't have - Describe the requirements that the stakeholders have agreed will not be implemented in a given system.

Through this technique, the users are requested to categorise the identified user stories under each group (Refer to Figure 3.7). The prioritisation was done through focus group discussion.

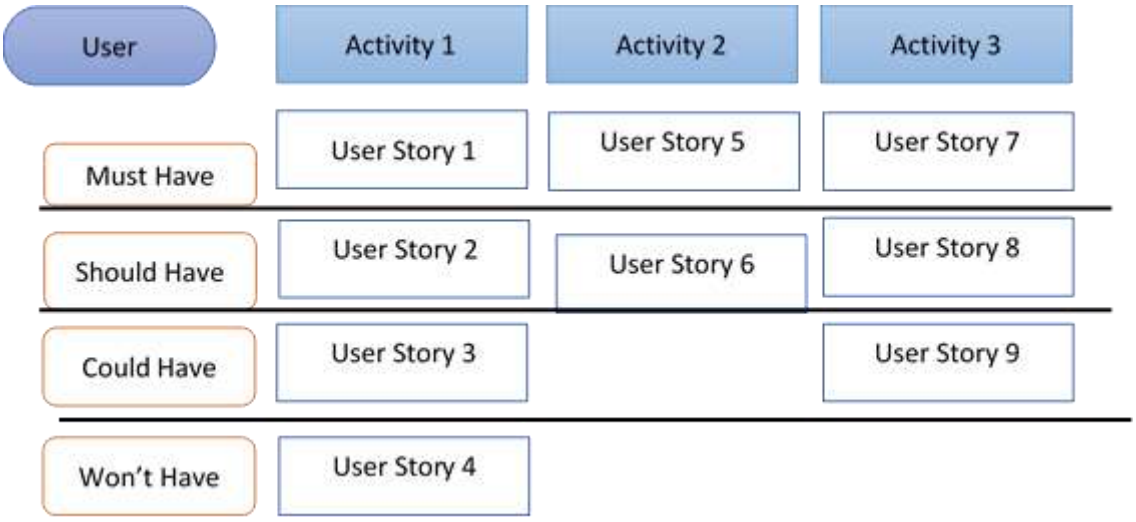


Figure 3.7: User Story Prioritization

3.3 Research Process

The research process is a series of multiple stages or actions which, are used to execute a research in an effective way (Singh & Singh, 2014). It describes the way of collecting, analysing and interpreting information to answer the research problem (Kumar, 2019). The research process is a journey of finding the answers to research questions (Kumar, 2011). The research process is shown in Figure 3.8.

At the initial phase, a background study was carried out to identify the knowledge gap in the research area. Accordingly, the background study developed the comprehensive research problem as "how to avoid the disconnection and develop the collaboration between the urban development process and disaster risk management process in an urban development project?" (Refer Section 1.2). Based on this, the research aim was set to develop a framework to support risk-sensitive urban development in Sri Lanka. Comprehensive literature review was conducted to achieve the first objectives and to contribute to all objectives. The state of the art in risk sensitive urban development was identified through the PRISMA method by a systematic review. The second and third objectives were achieved through the primary data and analysis. The final objective of the study, which was to develop a framework to support risk sensitive

urban development in Sri Lanka was achieved based on the analysed findings of objectives 1, 2 and 3 followed by validation interviews.

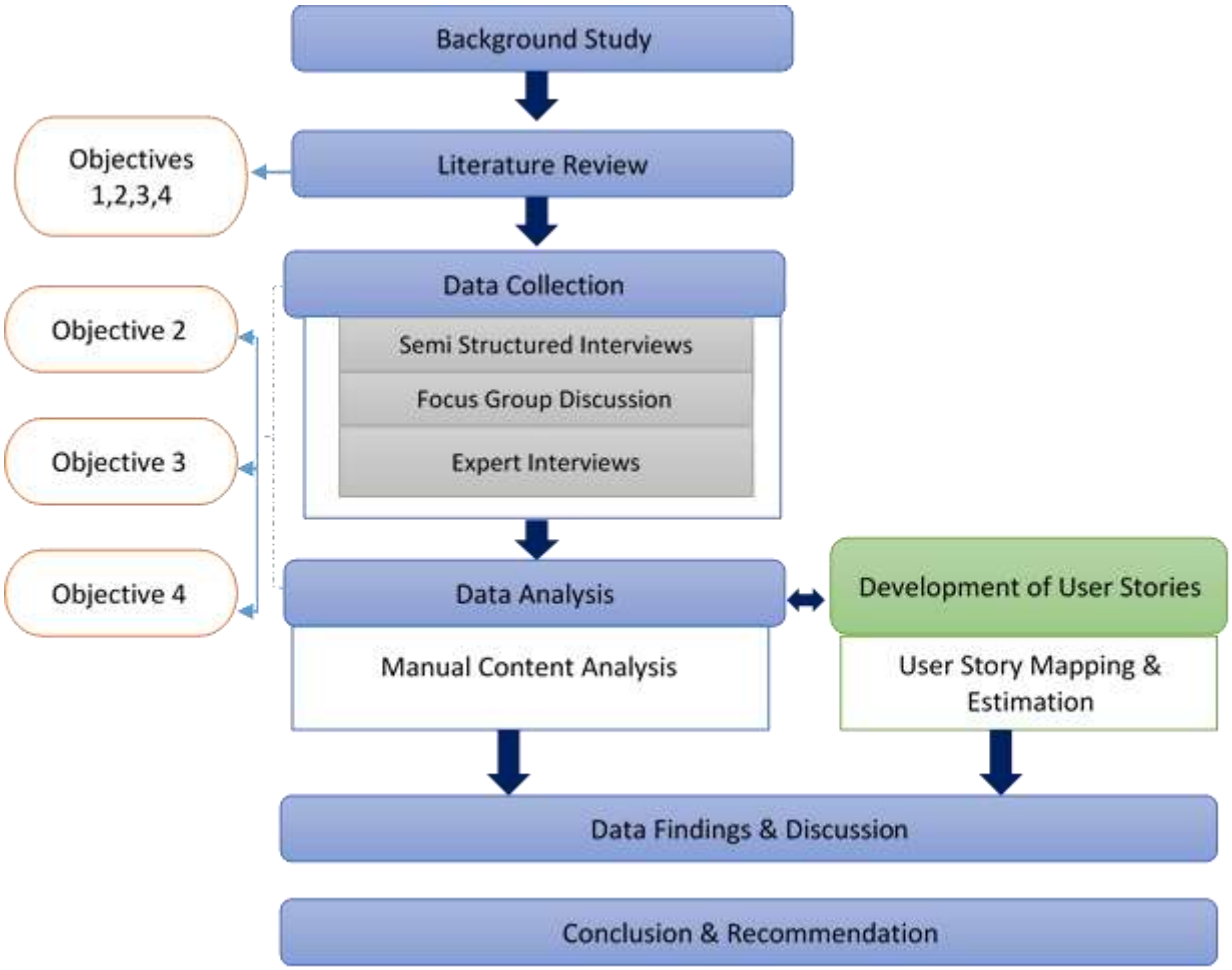


Figure 3.8: Research Process

3.4 Chapter summary

This Chapter provided a detailed view on the research methodology carried out in this study. Under the qualitative research choice, survey research strategy has been utilised to acquire an in-depth understanding on disaster management process used in urban development and user requirements for risk sensitive urban development approach. Interviews, focus group discussion and expert interviews were used in order to gather the relevant data. The collected data was then analysed using qualitative content analysis in order to derive the findings.

CHAPTER 4

4.0 DATA ANALYSIS AND FINDINGS

4.1 Introduction

This Chapter represented the comprehensive analysis of the collected data through semi structured interviews and focus group discussion in order to achieve the aim and objectives of the study.

4.2 Data Analysis of Interviews

The study mainly investigates the process used to identify, assess and manage disaster risks in urban development projects in Sri Lanka and capture the user requirements for an effective risk-sensitive urban development approach in Sri Lanka. In order to minimise the bias, the respondents were selected representing all the institutional levels (National, Provincial and District, Local and Community level) with related to the urban development and disaster risk management sectors. Respondents were interviewed until the collected data got saturated. Table 4.1 presents the profile of respondents.

Table 4.1: Profile of Respondents

Respondent Code	Designation	Experience (Years)
R1	Director Planning - UDA	22
R2	Director General Planning - UDA	24
R3	Director Environment & Landscape - UDA	25
R4	Assistant Director Environment & Landscape -UDA	23
R5	Assistant Director - DMC	16
R6	Director - NBRO	30

R7	Scientist - NBRO	10
R8	Director - Irrigation	24
R9	Chief Engineer - SLLDC	11
R10	Deputy General Manager - SLLDC	23
R11	Director Planning - CEA	12
R12	Director Project Management – UDA (Western Region)	22
R13	Director Planning – UDA (Sabaragamuwa Province)	25
R14	Assistant Director – DMC (Sothern Province)	26
R15	Director Planning - CMC	12
R16	CEO - FSLLGA	25
R17	District Officer - NBRO	18
R18	Grama Niladari	30
R19	Community Member	N/R
R20	Community Member	N/R

As per Table 4.1, the experience of the respondents demonstrated their expertise and skills with related to their working area (urban development or disaster risk management). The findings of semi structured interviews with regard to the disaster risk management process in Sri Lankan urban development projects and user requirements for an effective risk sensitive urban development approach in Sri Lanka have been presented below.

4.2.1 Disaster risk management process in Sri Lankan urban development projects

Under this sub section, it is explored the current disaster risk management process followed in the Sri Lankan urban development projects. The literature review has been explained the disaster risk management process under four (04) stages; disaster risk identification, disaster risk assessment, disaster risk mitigation and disaster risk monitoring. Accordingly, the data have analysed under those four stages of the disaster risk management by contextualising to the Sri Lankan urban development stage.

4.2.1.1 Disaster risk identification

Disaster risk identification step is the initial stage of disaster risk management process and it has been analysed under two aspects.

1. The disaster risks that are identified in the urban development projects (reality)
2. The disaster risks that should be identified in urban development projects (ideal)

Disaster Risks that are identified in Urban Development Projects (Reality)

According to the literature review, thirty (30) disaster risks have been identified from the urban development projects. Under the semi-structured interviews, the respondents were asked to contextualise the identified disaster risks in the Sri Lankan urban development projects. Table 4.2 analyses the disaster risks considered in the process of urban development projects (existing).

Table 4.2: Identified Disaster Risks in Urban Development Projects

DR	Disaster Risk	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
DR01	Climate change	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✗	✓	✗	✓	✓	✓	✓	✓
DR02	Declining ecosystems	✓	✓	✓	✓	✗	✓	✓	✓	✓	✗	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓
DR03	Pandemics and epidemics	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗	✓	✗	✓	✗	✗	✗	✗
DR04	Forest fire	✓	✗	✓	✓	✗	✓	✗	✗	✗	✗	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓
DR05	Soil erosion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DR06	Soil contamination	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓	✗	✗	✓	✓	✓	✗	✗	✗	✗
DR07	Environmental degradation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DR08	Over extraction of water	✓	✗	✓	✓	✗	✓	✓	✓	✗	✗	✓	✓	✗	✓	✗	✓	✓	✓	✗	✗
DR09	Clay soil shrinkage	✓	✓	✗	✗	✓	✓	✗	✗	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✗	✗
DR10	Water pollution	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DR11	Marine pollution	✓	✓	✓	✓	✓	✗	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓
DR12	Topography changes	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓
DR13	Carbon emission	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓
DR14	Heat island effect	✓	✗	✓	✓	✓	✓	✓	✗	✗	✗	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓
DR15	Air pollution	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓	✓
DR16	Water scarcity	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✗	✓	✓	✓	✗	✗
DR17	Rapid urbanisation/unplanned urbanisation	✓	✓	✓	✓	✓	✗	✗	✗	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓	✓

DR18	Land competition	✓	✓	✓	✓	✓	✗	✗	✗	✓	✓	✓	✗	✓	✗	✗	✓	✓	✓	✓	✓
DR19	Decreased vegetation cover	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓	✓
DR20	Changes in land use	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓
DR21	Unsustainable uses of natural resources	✓	✓	✓	✓	✗	✓	✓	✓	✗	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓	✓
DR22	Inappropriate land use planning	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓
DR23	Poverty and inequality	✓	✓	✗	✗	✓	✗	✗	✓	✓	✓	✗	✗	✓	✗	✗	✓	✗	✗	✓	✓
DR24	Poor health	✓	✓	✗	✗	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✓	✗	✗	✓	✓
DR25	Inadequate nutrition	✓	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗
DR26	Illiteracy	✓	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗
DR27	Deficient or non-existent sanitation	✓	✓	✗	✗	✓	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗	✓	✗	✗	✓	✓
DR28	Poor local governance	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✗	✗	✓	✗	✗	✓	✓	✓	✓	✓
DR29	Failure to regulate building standards	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓
DR30	Lack of adequate infrastructure and services	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓	✓

Table 4.2 presents the disaster risks identified in the process of urban development projects in Sri Lanka. When identifying the disaster risks related to the urban development projects, R1 declared that "*disaster risks may be vary from project to project and area to area. Therefore, we should clearly identify the disaster risks affected to the relevant projects to mitigate the disasters successfully*". However, R13 stated that having a common disaster risk checklist related to urban development

project may be a successful strategy when mitigating the disaster risk in urban development project. Moreover, majority of the respondents declared the necessity of having a common approach to identify the disaster risks related to urban development projects. When it comes to the environmental/climate related disaster risks, majority of the respondents have given a higher priority for the climate related disaster risks when compared to other disaster risk categories such urban development related, social related and governance related disaster risks (refer Table 2.7). However, R6 pinpointed that "*not only environmental or climate related disaster risks, but also social, development and governance related disaster risks needed to be considered when planning an urban development project"*. Furthermore, R6 stated that if the disaster management process not consider about the social, development and governance related disaster risks, it may cause disaster be more vulnerable to people. R16 also emphasised the importance of social related disaster risks identification since, majority of the people in Sri Lanka coming under the low income category level, social related disaster risks highly affected to the people who are living in vulnerable areas. R16 further elaborated that *if social related risks not consider when planning an urban development, it will create an accident to a severe disaster*".

According to the responses analysed in Table 4.2, environmental degradation and water pollution risks have been highlighted by all the respondents and urban developers consider those risks as critical when they are planning an urban development project Accordingly, both R3 and R4 declared that "*we are highly consider the environmental degradation risk and we calculate the environmental losses when planning an urban development project. Because, environmental degradation extremely generates disasters such as landslides and floods. When green vegetation removing from the environment, it caused to soil erosion and it lead to landslide risks in that area. Therefore, when we planning an urban development project, we always try to minimise the negative environmental impacts of the project*". Moreover, R2 also revealed that current urban development plans consider the environmental degradation risk each phase in the urban development process and many regulations have been formalised to follow when planning a project. Apart from

that, water pollution risk has been also identified as a critical risk generated with the urban development projects and R8 elaborated that "*pollution in rivers highly affects for flooding, therefore, they have given special concentration for water pollution risk when involving to urban development planning*". R15 also confirmed that water pollution risk is affected to the urban area flooding and they have taken many actions to mitigate the water pollution risk, when they are approving the urban development projects. Disaster management authorities have given guidelines to mitigate the flood risk due to the water pollution. In addition to the environmental degradation and water pollution risks, respondents have declared that few other important disaster risks such as soil erosion, topography changes, land use changes, inappropriate land use planning and failure to regulate building standards which may generate due to the increasement of the urban development projects.

Moreover, disaster risks such as climate change, declining ecosystems, forest fire, , soil contamination, over extraction of water, marine pollution, , carbon emission, heat island effect, air pollution, water scarcity, rapid urbanisation/unplanned urbanisation, land competition, decreased vegetation cover, changes in land use, unsustainable uses of natural resources, , poor local governance, , lack of adequate infrastructure and services have been also identified and considered in the current urban development process in Sri Lanka. Majority of the respondents have highlighted the severity of the climate change risk to the urban development process in Sri Lanka. However, R12 and R13 stated that climate change risk is not considered in the provincial level urban development process and R10 further revealed that local level urban planning process has also given less priority to assess climate change risk.

Moreover, R6 and R7 explained that soil erosion and contamination risk may also cause to the landslide risk, therefore, the urban development projects which are developed in hilly areas highly consider the soil erosion and soil contamination risk when planning an urban development project. R8 and R7 also confirmed the importance of considering the soil erosion and contamination risk during the urban development planning stage. As per Table 4.2, forest fire risk is highlighted by many

respondents but, R2 argued that "*forest fire risk is not affected to every urban development projects because it depends on the project location and topography. If we choose the project location in forest area, we have to consider it as a disaster risk*". Not only forest fire risk, but also the marine pollution and over extraction of water risk should be considered according to the project location.

When it comes to the urban development related and governance related disaster risks, unplanned rapid urbanisation has been highlighted by many respondents. R5, R19 and R20 have emphasised that unplanned rapid urbanisation is one of the major reason to generate the disasters and it lead the community to more vulnerable to the disasters because the unplanned development increase the disaster risk in urban areas. Furthermore, land competition, decreased vegetation cover, changes in land use, unsustainable uses of natural resources and inappropriate land use planning also needed to consider when planning an urban development project.

According to the empirical findings, it has been revealed that social related disaster risks such as poverty and inequality, poor health, inadequate nutrition, illiteracy and deficient or non-existent sanitation were not much considered in the urban development process. Not only social related disaster risks, but also the pandemics and clay soil shrinkage were also not considered as disaster risks related to the urban development projects in Sri Lanka. However, few respondents highlighted that pandemics have been considered in few development projects in Sri Lankan context in the present due to the past two-year issues and experiences gained from Covid 19. .

Disaster Risks that should be identified in Urban Development Projects (Ideal)

Table 4.3 identifies the disaster risks that should be identified in the process of urban development projects as per the opinions of interviewees.

Table 4.3: Disaster Risks should be identified in Urban Development Projects (Ideal)

DR	Disaster Risk	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
DR01	Climate change	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DR02	Declining ecosystems	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓
DR03	Pandemics and epidemics	✓	✗	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✓	✓	✓	✗	✗	✗	✗
DR04	Forest fire	✓	✗	✓	✓	✗	✓	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓
DR05	Soil erosion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DR06	Soil contamination	✓	✓	✗	✗	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
DR07	Environmental degradation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DR08	Over extraction of water	✓	✗	✓	✓	✗	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DR09	Clay soil shrinkage	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓	✓	✓	✗	✓	✓	✓	✗	✗
DR10	Water pollution	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DR11	Marine pollution	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓
DR12	Topography changes	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DR13	Carbon emission	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
DR14	Heat island effect	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DR15	Air pollution	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗

DR16	Water scarcity	✓	✓	✗	✗	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗
DR17	Rapid urbanisation/unplanned urbanisation	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓
DR18	Land competition	✓	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓
DR19	Decreased vegetation cover	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DR20	Changes in land use	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓
DR21	Unsustainable uses of natural resources	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DR22	Inappropriate land use planning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓
DR23	Poverty and inequality	✓	✓	✗	✗	✓	✓	✗	✓	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗	✓	✓
DR24	Poor health	✓	✓	✗	✗	✓	✓	✗	✗	✓	✓	✗	✗	✓	✗	✗	✓	✗	✓	✗	✗
DR25	Inadequate nutrition	✓	✓	✗	✗	✓	✓	✗	✗	✓	✓	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗
DR26	Illiteracy	✓	✓	✗	✗	✓	✓	✗	✗	✓	✓	✗	✗	✓	✗	✗	✓	✓	✓	✓	✓
DR27	Deficient or non-existent sanitation	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✗	✓	✗	✗	✓	✓	✓	✓	✓
DR28	Poor local governance	✓	✓	✗	✗	✓	✓	✗	✗	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓
DR29	Failure to regulate building standards	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓
DR30	Lack of adequate infrastructure and services	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓

Environment related risks | Urban development related risks | Social related risks | Governance related risks

Table 4.3 presents the disaster risks that should be identified and assessed in urban development projects. All the respondents have emphasised that climate change, soil

erosion, environmental degradation, water pollution, topography changes and unsustainable uses of natural resources must be considered and assessed when planning an urban development project. R5 stated that "*climate change in Sri Lanka has a direct impact to the disasters and specially for flood risk. Therefore, developers should give their utmost attention to climate change risk when they are planning urban development projects*". Moreover, R11 highlighted that higher pollution level in Sri Lanka has directly impact to climatic change and it affects to disaster risk increasement. Soil erosion has been also considered as critical risk and R6 elaborated that "*when the unplanned development are risen in the country, it caused to reduce the vegetation in the land. Then, it directly caused for landslides in that development area*". Furthermore, R2 pinpointed that "*when doing the development projects, we have to cut the hilly areas and remove the vegetation near that area. It will directly cause for landslides and we have given instruction to follow 30^0 angle soil cutting method in order to prevent from the soil erosion and landslide disaster*". Under the environmental or climate related disaster risk category, declining eco systems, topography changes and heat island effect have been highlighted by all the respondents. Further, R7 emphasised that heat island effect also has a greater impact for disasters and it is also needed to be concerned when planning urban developments.

Disaster risks related to the urban development also have been highlighted by all the respondents and unplanned rapid urbanisation has been considered as one of the critical disaster risk in Sri Lankan urban development projects. Since people prefer to build their houses near to city areas has caused to increase the disaster risks in urban areas. R1 said that "*Colombo district has a greater flood risk due to this unplanned developments and other sub urban areas are also facing this issue currently. Therefore, we should highly concern about this unplanned rapid urbanisation risk we should take quick actions to manage it*". Furthermore, R2 elaborated that decreasing vegetation cover will generate landslide and flood risk in Sri Lankan urban areas. In order to protect the vegetation cover, efficient land use plans needed to be developed in initial stage of the development process. Apart from that R11 highlighted that changes in land use and unsustainable uses of natural resources needed to be concerned

as disaster risks and if it is not considered it will create resource scarcity in future. Under the governance related disaster risks, failure to regulate building standards and lack of adequate infrastructure have been identified as highly considered risks which increase urban disasters.

In addition to that, majority of the respondents have highlighted the social related disaster risks such as illiteracy, non-existent sanitisation and R5 pinpointed that "*illiteracy is a critical issue for disaster awareness. Because, if people do not have knowledge to understand the instruction given to protect from disasters, it lead community to more vulnerable to the disasters*". Further, R19 and R20 also confirmed the opinion given by R5 and highlighted that poverty, non-existent sanitisation and illiteracy are the major social issues during and post disaster period. They further elaborated that "*it is very difficult to handle the community in a disaster event because of the illiteracy and poverty issues. It is the major reason of creating less awareness in disaster management*". However, majority of the respondents said that poor health, inadequate nutrition and pandemics not have been needed to give more considered as disaster risks when planning urban development projects.

Table 4.2 represents the disaster risks considered in the current urban development process (existing) and Table 4.3 shows the disaster risks should be identified (ideal) in the urban development process in Sri Lanka. According to the analysis of Table 4.2 and Table 4.3, there is a gap between existing identification and ideal identification. Figure 4.1 compares the disaster risks that are identified in the urban development process (existing) with the disaster risks that are expected to be identified (ideal). Accordingly, it clearly indicates the gap between the existing and ideal situations in terms of disaster risks identification.

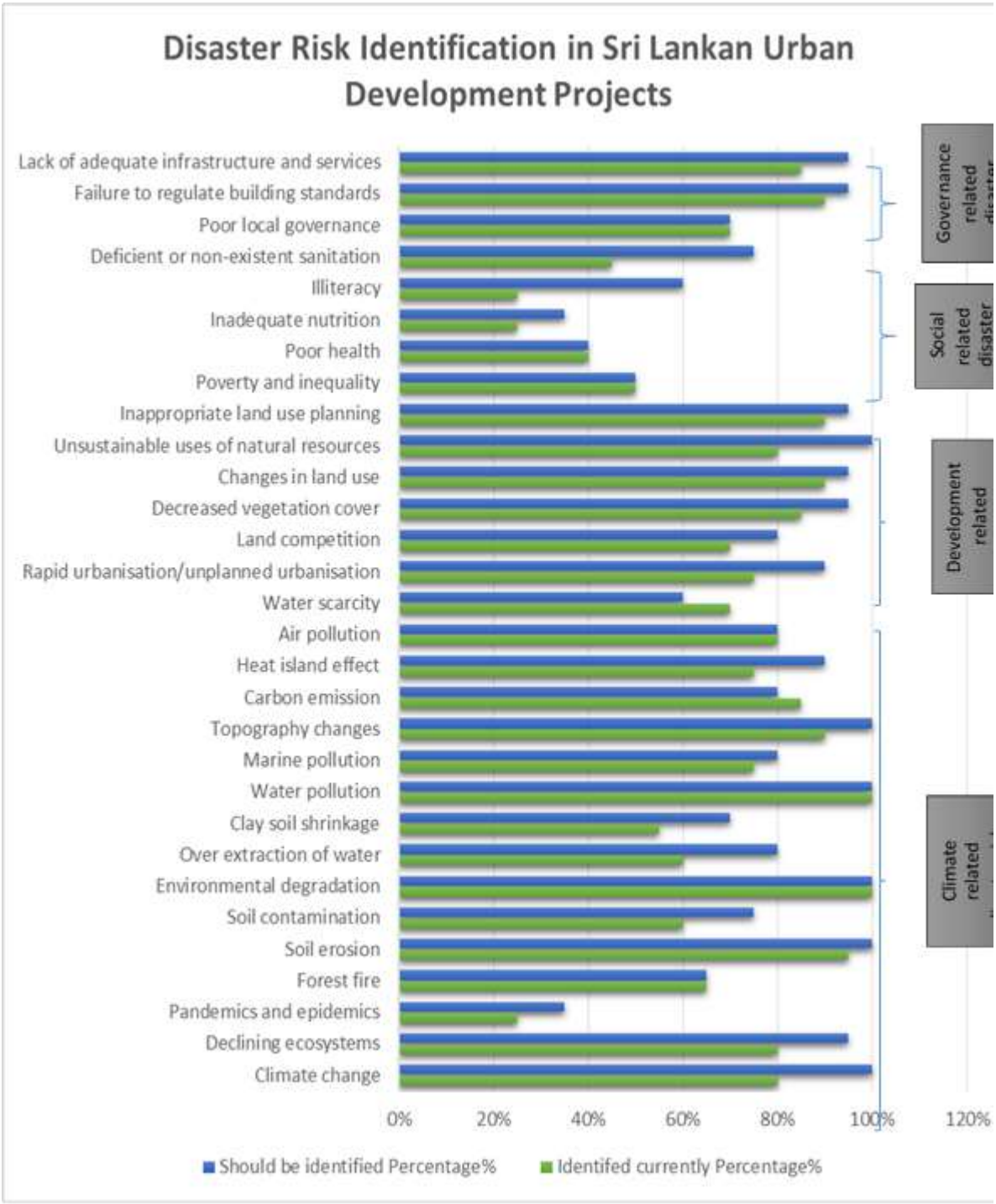


Figure 4.1: Disaster Risks in Sri Lankan Urban Development Projects

Stages of Urban Development for Disaster Risks Identification

According to the literature, the urban development process is consisted four stages; pre design stage, design and development stage, use maintenance & management stage and decline/demolition stage. Respondents were asked to identify the appropriate stages of urban development for each disaster risk, which is depicted in Table 4.4.

Table 4.4: Disaster Risk Identification Stage

DR	Disaster Risk	Number of responses			
		Pre-Design Stage	Design and Development Stage	Use, Management & Maintenance Stage	Decline/Demolition Stage
DR01	Climate change	20	20	20	-
DR02	Declining ecosystems	19	16	-	-
DR03	Pandemics and epidemics	-	04	07	-
DR04	Forest fire	13	13	13	10
DR05	Soil erosion	20	20	20	20
DR06	Soil contamination	10	15	15	15
DR07	Environmental degradation	20	20	20	20
DR08	Over extraction of water	16	16	16	-
DR09	Clay soil shrinkage	14	14	-	-
DR10	Water pollution	20	20	20	10
DR11	Marine pollution	12	16	16	16
DR12	Topography changes	20	20	20	07
DR13	Carbon emission	16	16	16	16
DR14	Heat island effect	18	18	18	10
DR15	Air pollution	16	16	16	16
DR16	Water scarcity	12	12	12	-
DR17	Rapid urbanisation/unplanned urbanisation	18	-	-	-
DR18	Land competition	16	-	-	-

DR19	Decreased vegetation cover	19	19	19	19
DR20	Changes in land use	19	19	19	19
DR21	Unsustainable uses of natural resources	20	20	20	10
DR22	Inappropriate land use planning	19	-	-	-
DR23	Poverty and inequality	10	-	10	-
DR24	Poor health	-	-	08	-
DR25	Inadequate nutrition	-	-	07	-
DR26	Illiteracy	-	-	12	-
DR27	Deficient or non-existent sanitation	15	-	-	-
DR28	Poor local governance	14	-	-	-
DR29	Failure to regulate building standards	19	-	-	-
DR30	Lack of adequate infrastructure and services	19	-	-	-

According to the above analysis, the numbers are derived by the frequency of responses. Overall, all the disaster risks except pandemics, poor health, inadequate nutrition and illiteracy risks should have been identified in pre design stage of the development. R6 emphasised that "*pre design stage is the ideal stage to identify the disaster risks and it is the successful way of achieving the risk sensitive urban development*". However, there are some risks needed to be concerned and assessed in whole life cycle of the development process. According to the responses, forest fire, soil erosion, soil contamination, environmental degradation, water pollution, marine pollution, topography changes, carbon emission, heat island effect, air pollution, decreased vegetation cover, changes in land use and unsustainable uses of natural resources risks are considered in the whole development cycle of the urban development project. The disaster risk identification in different development stages has been shown in Figure 4.2.

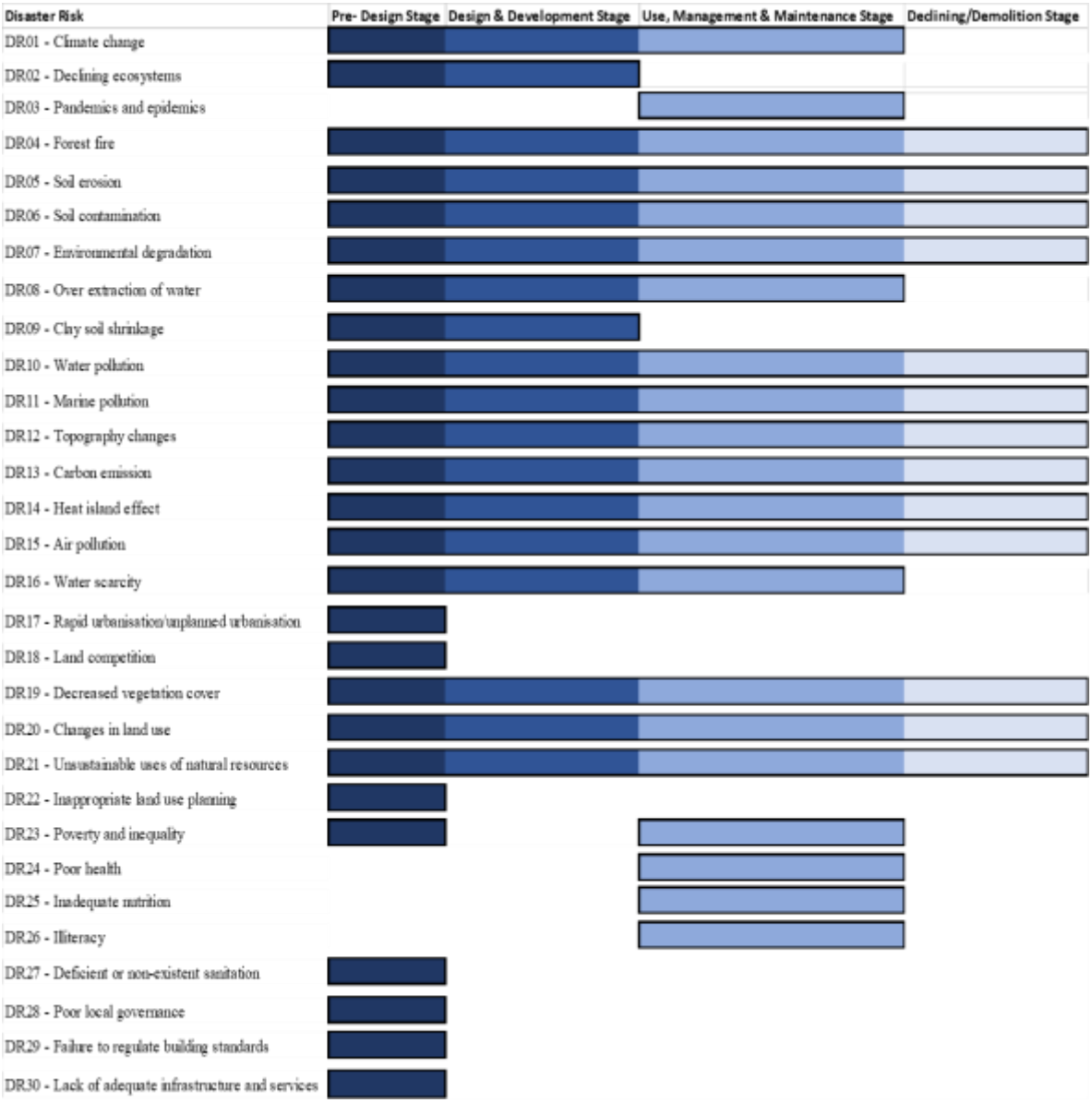


Figure 4.2: Disaster Risk Identification according to the Development Stages

Approaches for Disaster Risk Identification

Under the risk identification step, risk identification approach is utmost important in urban development projects. Literature review has explored few risk identification approaches used in worldwide urban development projects in order to mitigate the disaster risk. Disaster risk identification approaches used in Sri Lankan urban development projects have been categorised under two areas such as disaster risk

identification tools and techniques. Accordingly, several disaster risk identification tools and techniques were identified and depicted in Figure 4.3. Under that, R6 declared that "*NBRO has a higher responsibility to identify the disaster risks related to urban development project and we use hazard maps, land use maps, GIS maps and field study reports to identify the disaster risks in the areas which are planning to develop*". Furthermore, R7 stated that NBRO is mainly focused to mitigate landslide disaster risk and they give instruction to developers about landslide disaster mitigation strategies. Adding to that R8 elaborated that they have used hydrology and drainage analysis method to identify the flood risk related to the urban development projects and they also use land use maps and vulnerability curves when doing the risk sensitivity analysis. In addition to that R1 expressed that UDA create and refer the land use maps before planning the projects. Through the GIS data sheets received from SLLDC, NBRO and internal GIS department, UDA design the urban development projects. Furthermore, R2 stated that UDA consider income level data sheets, field study reports, GIS maps, risk management guidelines, risk management plans, vulnerability curves, data collected from district and local levels, risk registers are used as disaster risk identification tools and risk sensitivity analysis, risk breakdown structures, brainstorming method, cause and effect diagram method, document review, interviews & focus group discussions, traffic impact assessment, local hazard map creation techniques were followed when planning an urban development project. Accordingly, Figure 4.3 summarises the tools and techniques used for disaster risk identification in Sri Lankan urban development projects.

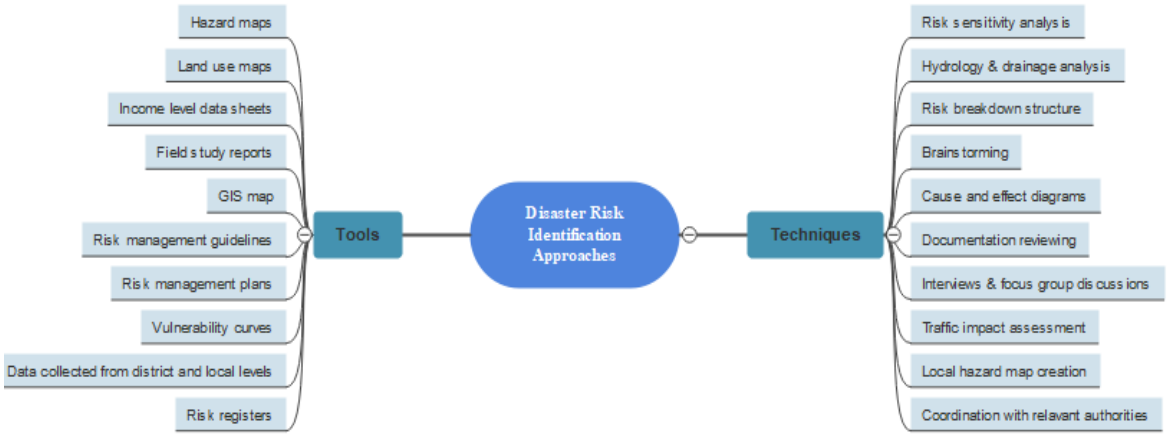


Figure 4.3: Disaster Risk Identification Approaches

As per Figure 4.3, hazard maps, land use maps, income level data sheets, field study reports, GIS maps, risk management guidelines, risk management plans, vulnerability curves, data collected from district and local levels and risk registers use as disaster risk identification tools and risk sensitivity analysis, hydrology & drainage analysis, risk breakdown structures, brainstorming method, cause and effect diagram method, document review, interviews & focus group discussions, traffic impact assessment, local hazard map creation and coordination among relevant authorities use as disaster risk identification techniques in urban development process in Sri Lanka.

Sources Used for Disaster Risk Identification

As discussed in the above section, risk identification approaches based on the sources used for disaster risk identification. According to R1, there are many sources used when planning the urban development projects and they have been received many sources from other related authorities to manage the disaster risks related to the planned urban development projects. According to the details given by R1 and R2 many authorities related to the urban development and disaster risk management in Sri Lanka involve with UDA to the process of urban disaster risk management currently. As per that, NBRO, DMC, Irrigation department, CEA, SLLDC, Meteorology department, CMC, government, Local authorities, and community provide information for disaster risk identification process in the urban development. R3 and

R4 elaborated that, "*UDA provides development plans, guidelines such as soil cutting methods (30^0 angle soil cutting method), infrastructure details, government policy details, Environmental Impact Assessment (EIA) reports, GIS databases, other institutional guidelines, population data, green building certification details etc*". Furthermore, R6 and R7 expressed that NBRO provides landslide maps, Initial Environmental Examination (IEE) reports, EIA report, GIS data sheets, research and survey reports, green building clearance reports, Environmental & Social Management Plans (ESMP) etc. R9 stated that soil testing reports, GIS data, land use maps, hazard maps and guidelines related to the sites were issued by SLLDC and R10 has also confirmed the statement of R9. In addition to that, R11 revealed that EIA and IEE were done by CEA also and Meteorology department provides rain fall data sheets, climate change reports, weather forecasting data sheets, drought and hazard data and early weather reports to UDA when planning an urban development projects. Moreover, R5 declared that "*Disaster management and preparedness plans, risk registers, flood maps, landslide maps, hazard maps, vulnerability data bases, post disaster reconstruction plans and survey details are provided by DMC and hydrological data sheets and flood maps were taken from the Irrigation department*". Further to that, R16 explored that local level land use maps, drainage and underground services details, local area vulnerable reports and local area vulnerable people details provided by local level authorities and community. Accordingly, Figure 4.4 concludes the sources used for disaster risk identification. The common sources that are used by more than one entities are highlighted in Figure 4.4.

Figure 4.4: Sources used for Disaster Risk Identification

4.2.1.2 Disaster risk assessment

Disaster risk assessment is the second stage of the disaster risk management process and there are qualitative and quantitative approaches used to assess the risk.

Disaster Risk Assessment Approaches

Risk assessment approaches have been identified under qualitative and quantitative categories. R2 emphasised that "*we develop risk breakdown structure related to the planned urban projects and categorise the identified risks as high, medium and low. Thereafter, we develop mitigation strategies for the critical risk and we try to minimise the medium and low level risks also when planning the development*". Furthermore, R1 expressed that thematic risk maps are developed based on the identified disaster risks and using those maps for designing the urban projects accordingly. It was also emphasised by R6 that human settlement risk zonation maps are used by NBRO to assess the landslide risk in Sri Lanka. Accordingly, there are several approaches to developing urban settlement risk maps, including physical risk mapping, social risk mapping, environmental risk mapping, and, in some cases, economic risk mapping. A physical risk map, for example, will indicate the physical risk of a hazard. This may or may not have an immediate impact on people or settlements. All the same, the human settlement risk map is a summary of all of the previous approaches or factors. However, R7 argued that "*there is no exact adapted method for disaster risk assessment related to the urban development projects in Sri Lanka and commonly used risk assessment approaches are incorporated to the current urban development process, when doing the risk assessment*". R8 declared that flood hazard maps and flood simulation models are used as qualitative assessment approaches and flood risk index calculation is done under the quantitative assessments. Moreover, R1 elaborated that landslide vulnerability assessment, GIS data analysis, landslide inventory maps, landslide distribution and density maps are created by the details given from NBRO Sri Lanka when assessing the risks affected to the urban development projects. In addition to that, R14 declared that Tsunami hazard zonation maps are created to assess the risk of Tsunami and they have developed the preparedness plans accordingly. Further to the above declared approaches, R9 represented that risk breakdown structures, risk matrix, GIS data, soil testing index were assessed by the SLLDC and R11 elaborated that social vulnerability index, economic vulnerability index and risk breakdown structures are used by CEA.As per the empirical findings, Figure 4.5

illustrates the summary of the disaster risk assessment approaches used in Sri Lankan urban development projects.

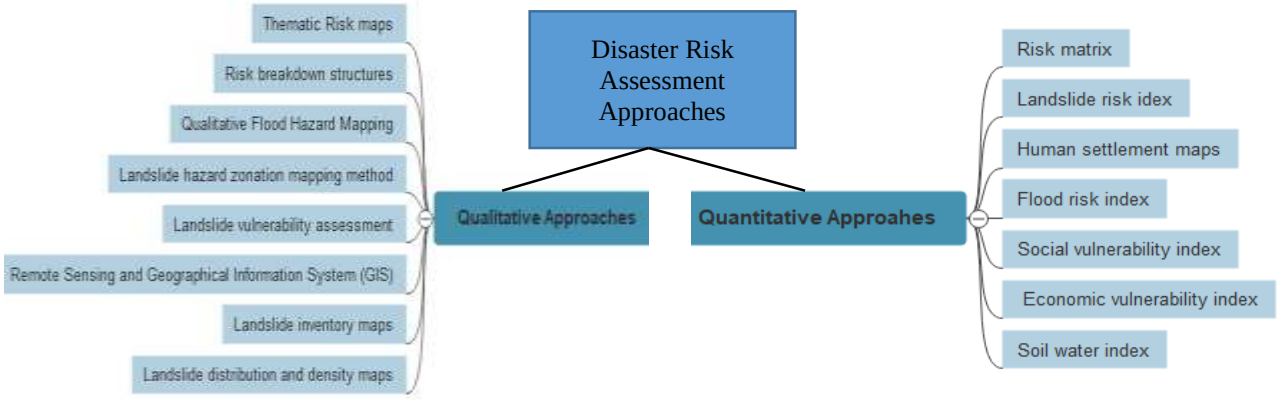


Figure 4.5: Disaster Risk Assessment Approaches

According to the empirical findings, the majority of the participants have stated that risk matrix, risk breakdown structures and thematic risk maps are used to assess many types of disasters commonly and it provides an overall picture of the disaster risk level which may affect to the planned urban development projects.

4.2.1.3 Disaster risk mitigation

Disaster risk mitigation is the third step of the disaster risk management process and disaster risk mitigation activities that are implemented in the current urban development process have been discussed in the below section. Identified disaster risks by using risk identification tools and techniques are assessed and prioritised the risks as high, medium and low levels. Thereafter, risk mitigation strategies were identified to manage the disaster risks expected for the urban development

Strategies Used for Disaster Risk Mitigation

Strategies that are used in the urban development process in Sri Lanka have been identified under the key disasters that may be affected to the Sri Lankan urban development projects.

Accordingly, R6 stated that NBRO has taken strategies to mitigate landslide risk and they have developed proper guidelines which should be followed when arranging the project locations. Moreover, they have given instructions to develop retaining walls for landslide risk areas near the project location and provide details about surface erosion control measures. In addition to that, R7 elaborated that "*we have prepared landslides hazard maps and we give instruction to developers to avoid those areas when they are planning urban development projects*". Also, R2 revealed that NBRO has given instructions about land cutting slope geometries, removing the deposited debris when doing the excavations for the project and doing an initial landslide risk assessment to develop land plans accordingly. Moreover, it has been focused to improve water drainage system, awareness and preparedness of landslide risk by UDA to mitigate the risk severity.

When it comes to flood disaster risks mitigation, R8 has pinpointed that they have developed flood simulation models for main river basins (Kalani, Kalu, Nilwala, Gin, Mahaweli, Walawe, Bentara etc.) in Sri Lanka as decision making tools to warn about the flood disaster. Also, they have prepared flood inundation maps and informed UDA, DMC and other relevant authorities the areas that may be affected due to the flood risk in Sri Lanka. Furthermore, they have used early warning systems to identify the flood risk and they have coordinated with DMC, Met department, NBRO and other relevant authorities to manage the flood risk. In addition to that, R13 explained that river cleaning near the development areas is a very successful method of controlling the flood and it was confirmed by R16, R19 and R20 also.

Under the cyclones and droughts, R2 stated that UDA has coordinated with Met department, DMC, Agriculture department, Coastal conservation department and other relevant parties to identify the cyclone prone areas and mitigate the risk by taking instructions from them. R5 has revealed that "*we have prepared and informed about the cyclone prone areas to developers and they are asked to plan the project without using those areas*". In order to mitigate the risk of droughts, R3 and R4 explained that UDA has analysed the rainfall data, surface run off data, land use patterns, soil types,

population density and water use patterns with the support of Agriculture and Survey departments in Sri Lanka. Through these analysis, they have classified the drought prone areas and identified the possible strategies that they can take to mitigate the drought risk when they are planning urban development projects.

In order to prevent from tsunami risk, DMC, Met department and Coastal conservation department have given instructions to UDA for planning safe urban development projects in Sri Lanka. Accordingly, R5 expressed that DMC has marked the tsunami high risk area zones and given instructions to UDA to consider those criteria when they are planning urban development projects. Apart from that, R14 also stated that "*we inform the community to build their houses by keeping at least 100m distance to the sea*". As per the above findings, UDA has incorporated with many authorities to mitigate the disaster risks which may be affected to the urban development projects in Sri Lanka and summary of the findings are presented in Figure 4.6.

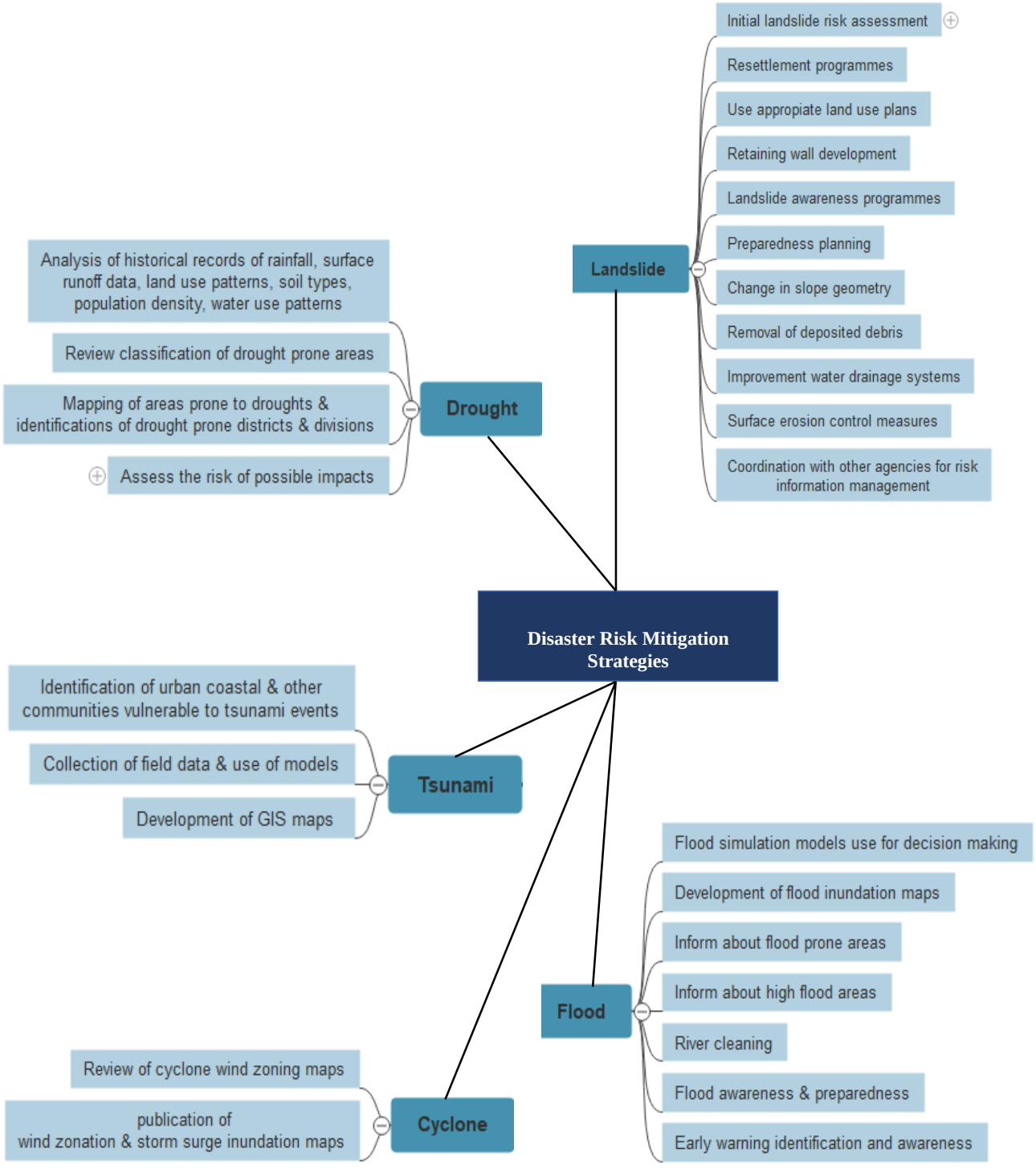


Figure 4.6: Disaster Risk Mitigation Strategies

4.2.1.4 Disaster risk management monitoring

Risk management monitoring is the final step of the disaster risk management process. According to the literature review, disaster risk monitoring is a continual process that managing the stakeholders and check the implemented actions. However, empirical findings identified the lack of focusing of disaster risks management monitoring methods, when considering the Sri Lankan urban development projects. Therefore, limited risk management monitoring approaches were identified from the interviews.

Disaster Risk Management Monitoring Approaches

Under the disaster risk management monitoring, R5 stated that, DMC periodically checks the risk mitigation strategies and updated risk conditions by forming risk monitoring committees. Also, DMC is responsible to held disaster awareness programmes and currently they have discussed the issues with local level authorities and community to identify the any additional disaster risks and check the efficiency of the taken strategies. R2 also declared that, UDA has coordinated with DMC to monitor the efficiency of risk mitigation strategies that have taken during the urban development process. Figure 4.7 represents the identified monitoring approaches.

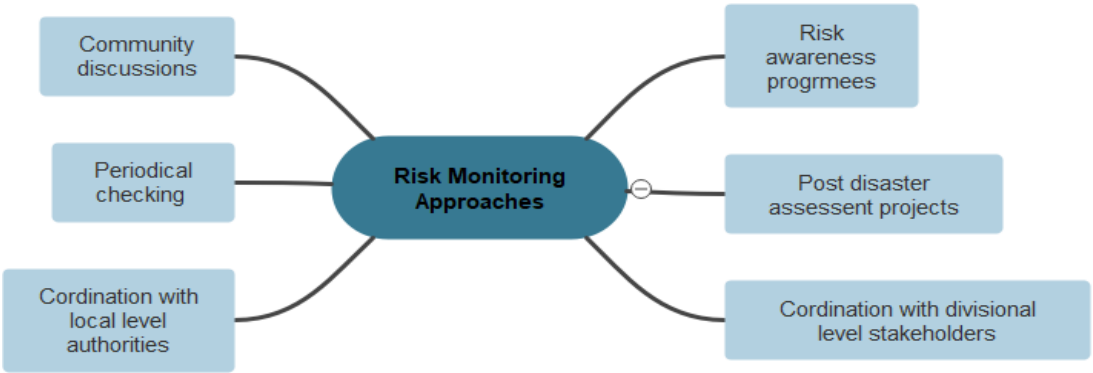


Figure 4.7: Disaster Risk Monitoring Approaches

4.2.1.5 Stakeholders involved in disaster risk management process

Stakeholders related to urban development and disaster risk management have been identified with their responsibilities. According to the literature, stakeholders have

been categorised under four levels; national, provincial & district, local and community levels.

National Level Users

According to the empirical findings, there are 13 national level users, and their roles and responsibilities towards disaster risk management in the urban development projects Sri Lanka have been identified in Table 4.5.

Table 4.5: Roles & Responsibilities towards Disaster Risk Management - National Level Users

User	Roles and responsibilities
UDA	Provide land use plans
	Provide building standards and regulations
	Provide instructions for development
	Provide fund for disaster management
	Provide technical assistance
	Provide risk resilience development plans
	Select suitable lands for developments
	Provide approvals for risk resilience projects
DMC	Disaster risk management planning
	Public Awareness, Education and Training
	Disaster risk management guideline preparation
	Provide technical assistance for DRM
	Post disaster risk management
	Disaster risk monitoring
	Provide early warnings about disasters
NBRO	Provide detail landslide hazard maps for urban areas
	Develop GIS maps and risk maps
	Geological and geotechnical investigation for collection of necessary field data
	Identification of risk areas/locations and assess the hazard impacts
	Updated Landslide Hazard Zoning (LHZ) maps
Irrigation Department	Establishment of effective flood hazard Early Warning system
	Identify the high risk reservoirs
	Create inundation maps, GIS maps

	Rainfall data analysis
	Development of appropriate simulation models
	Assessment of existing flood protection methods
SLLDC	Provide soil testing reports
	Approve risk resilience projects
	State land administration, management, land use planning and supervision
	Supervision of activities related to the land settlement
	Proper alienation of lands required for the development activities
	Supervision of land surveying and mapping and providing land information and related services
CEA	Environmental Impact Assessment (EIA)
	Provide environmental recommendations
	Testing facilities are available for noise and air quality
	Provide assistance for waste management
	Provide Environmental Sensitive Area Maps
Coast Conservation department	Identify vulnerable areas (for tsunami)
	Monitoring of marine & coastal habitats
	Risk assessment
	Developing of Tsunami hazard zonation maps and coastal erosion maps
Meteorology department	Updated wind zoning and storm surge hazard maps
	Provide rainfall data
	Provide weather forecasting reports
	Provide assistance on climate change
Agriculture department	Provide drought-prone area maps
	Provide Micro-climatic maps
	Assess the risk of possible impacts
	Analysis of historical records
RDA	Provide Database on transportation accidents
	Provide traffic details
	Develop infrastructure
CEB & NWSDB	Provide electricity safely
	Provide continuous water supply
Government	Fund allocation for disaster preparedness
	Initiate risk resilience projects

	Disaster risk mitigation policy creation
	Intergovernmental coordination
	Coordinate national level disaster management institution with political parties

As per Table 4.5 importance of the duties of national level authorities have been gathered. Accordingly, each authority has different duties on risk management in urban development projects, but no collaboration and awareness between the authorities.

Provincial & District Level Users

Provincial and district level users have explained their roles and responsibilities towards disaster risk management in urban development process in Sri Lanka. Furthermore, interviews carried out with national level, local level and community level have been also pinpointed the duties that they are expecting from provincial and district level users regarding disaster risk management. Table 4.6 summarises the identified roles and responsibilities of provincial and district level users.

Table 4.6: Roles & Responsibilities towards Disaster Risk Management - Provincial & District Level Users

User	Roles & responsibilities
Provincial and district level authorities	Implement and monitor national level policies and guidelines
	Coordination among national level institutions
	Awareness programmes
	Provide instruction for developments
	Identify high risk areas

Local Level Users

Local level users have explained their roles and responsibilities towards disaster risk management in urban development process in Sri Lanka. Furthermore, authorities in other stakeholder levels have been also expressed the duties that they are expecting

from local level users regarding disaster risk management. Table 4.7 represents the identified roles and responsibilities of local level users towards the disaster risk management in Sri Lankan urban development projects.

Table 4.7: Roles & Responsibilities towards Disaster Risk Management - Local Level Users

User	Roles & responsibilities
Local level authorities	Implement and adhere to national, provincial and district level policies and guidelines
	Community awareness
	Local level land use maps creation
	Identify high risk areas
	Provide instruction for local level developments
	Coordination among national, provincial and district level institutions

Community Level Users

Community level users and other stakeholder level users have explained the roles and responsibilities of community level towards disaster risk management in urban development process in Sri Lanka. Table 4.8 represents the identified roles and responsibilities of community level users towards the disaster risk management in Sri Lankan urban development projects.

Table 4.8: Roles & Responsibilities towards Disaster Risk Management - Community Level Users

User	Roles & responsibilities
Private Companies	Provide technical assistance
	Adhere and follow the guidelines
	Local level land use maps creation
	Take comprehensive insurance plan
	Proper waste management
Community/Society	Adhere to disaster resilience development guidelines

	Aware about disaster preparedness
	Collaborate coordination with local level authorities
	Identify and mitigate possible risks
	Protect environment

4.2.1.6 Strengths and weaknesses of the disaster risk management in urban development projects

Under the disaster risk management in the urban development projects in Sri Lanka, strengths and weaknesses have been identified by the participants involved under national, provincial, district, local and community levels. According to the empirical findings, strengths and weaknesses identified are discussed and summarised in below section separately.

Strengths

Under the topic of strengths in disaster risk management process used for Sri Lankan urban development projects, majority of the participants highlighted the expert knowledge available to manage the disaster risk in Sri Lanka. In support of that, R12 stated that "*there are enough regulations, rules and guidelines with many expertise authorities available in Sri Lanka and it is one of the big strengths to achieve the efficiency of disaster management*". Moreover, R5 declared that available technical facilities, early warning systems, forecasting methods are useful resources when planning an urban development projects. Adding to that, R12 emphasised the value of historical database currently available in Sri Lanka and it was appreciated by R1 also. Accordingly, strengths of the disaster risk management in urban development projects are summerised in Figure 4.8.

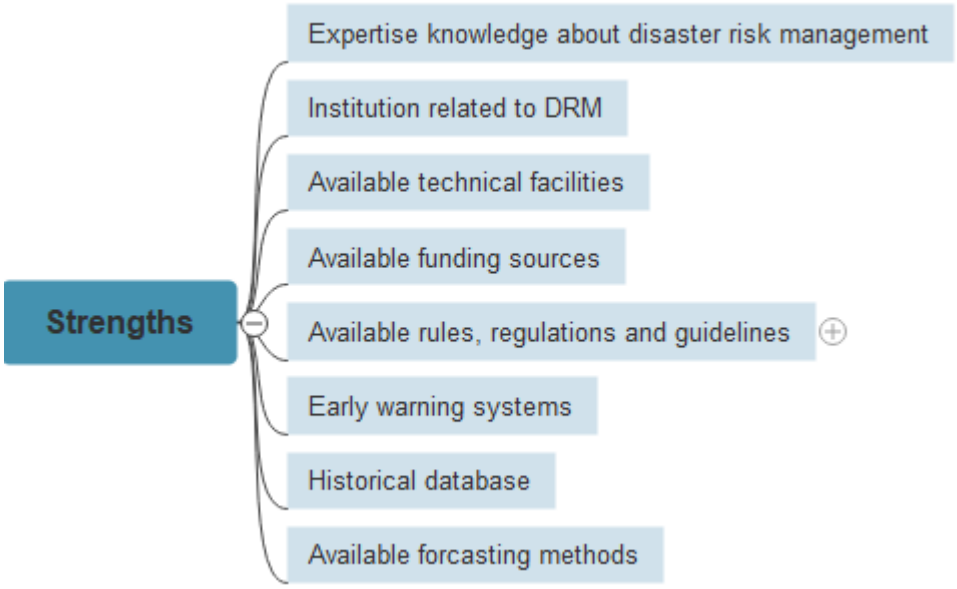


Figure 4.8: Strengths of Disaster risk Management Process

Weaknesses

There are many weaknesses identified related to the disaster risk management process followed in Sri Lankan urban development. Even though there are enough regulations and guidelines, all the participants have highlighted that, still disasters are highly affected the people in Sri Lanka. R2 expressed that less collaboration between the institutions, lack of financial resources and high technological devices and weaknesses in the pre disaster plans are key weaknesses noticed by UDA. Moreover, R3 and R4 elaborated that record keeping issues, frequent political changes, policy and legal framework issues are also affected to reduce the efficiency of the disaster risk management process. It was remarkably highlighted by R7 that "*according to my view, absence of the overall development plan for urban areas is the major weakness that I have noticed in the current process"* and it has been confirmed by R6 also. Apart from that, R5 explained that due to the unavailability of collaborative information sharing system, it caused to less awareness about disaster risk management methods among stakeholders involved urban development. Furthermore, R5 stated that, DMC has identified that negative attitudes about disaster risk management also lead people to be

more vulnerable to the disasters. When it comes to the provincial, district and local level risk management, there are lot of issues arisen due to the less collaboration among the authorities and issues arisen during the information sharing. R16 expressed that "less awareness, less monitoring, less maintenance and lack of financial resources caused to increase the local area disaster risk related to the urban development projects. In addition to that, R17 and R18 also explained the issues arisen in provincial, district and local stakeholder levels, when planning an urban development projects. Moreover, R19 and R20 highlighted the issues of information sharing and they have stated that, it is highly affected to the development doing under community levels. Accordingly, identified weaknesses are summarised in Figure 4.9.

Figure 4.9: Weaknesses of Disaster Risk Management Process

According to the above analysis, there are many weaknesses than the strengths of the disaster risk management process related to the Sri Lankan urban development projects. In order to avoid the weaknesses, participants have given suggestions to improve the disaster risk management process.

4.2.1.7 Suggestions to improve the disaster risk management process in urban development projects

In order to improve the disaster risk management process used in Sri Lankan urban development projects, all the participants have highlighted the importance of risk sensitive urban development approach. R7 declared that "*in order to mitigate the disaster risks that happened in Sri Lanka, we should follow risk sensitive urban development*". In addition that, an overall development plan should be developed for all the urban areas and a supportive, user friendly information sharing system should

be developed in future periods. Also, it was suggested by R5 that sufficient fund allocation, community awareness, modern technological device usage, disaster risk monitoring method and coordination among the authorities should be initiated and developed in future disaster management process. Furthermore, R1 explained the importance of having stable political frameworks and updating the building codes will be improved the disaster management process used in Sri Lankan urban development projects. Figure 4.10 illustrates the summary of the findings.

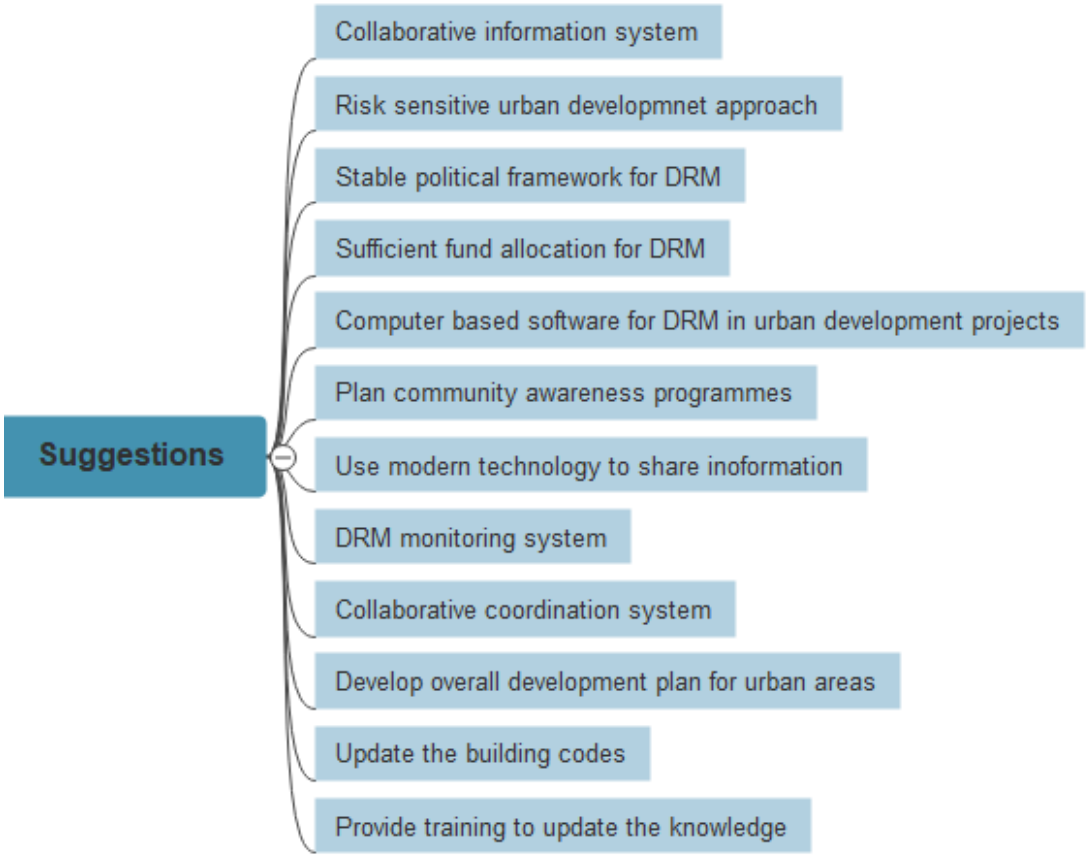


Figure 4.10: Suggestions to Improve the Disaster Risk Management Process

4.2.2 User requirement analysis for an effective risk-sensitive urban development approach in Sri Lanka

The data collected under the semi structured interviews and literature review, the users have been categorised into different levels such as national, provincial & district, local and community. This section analyses the user story mapping process for all the above user levels.

4.2.2.1 Development of the user story map using semi-structured interviews

As per the findings of the interviews the user story maps were developed with regard to each user level as discussed below.

User 1 - Officers in disaster risk management in urban development in National level

Initially, the major activities of User 1 were identified to build up the backbone.

According to the R1 opinion, there should be a **collaborative information sharing method** for risk sensitive urban development in Sri Lanka. The national level officers are responsible for planning the risk sensitive urban development approaches and R2 also elaborated that "*we need a collaborative methods to share national level information to other level's stakeholders in order to become a risk sensitive urban development*". Furthermore, R2 stated that the details given by the relevant institutions such as NBRO, DMC, SLLDC, Irrigation, CMC, Met department, Coastal conservation department, CEA and other provincial, district and local level authorities should be consolidate to and easily accessible to the every stakeholders who are related to the urban development planning in Sri Lanka. Through this collaborative information system, R2 declared that "*we can plan the project in order to face the disasters by managing the expected disaster risks before it affects severely*".

Apart from that R5 highlighted that there should be a **linkage between relevant authorities** such as NBRO, DMC, SLLDC, Irrigation, CMC, Met department, Coastal conservation department, CEA, CEB, NWSDB and other provincial, district and local level authorities. Furthermore, R5 described the importance of the connectivity of

these organisations when planning urban development project. R5 elaborated that "*In order to manage the disaster risks in a project, all the relevant authorities should take actions on time and all the institutions should have a proper understanding about the roles and responsibilities of other authorities as well*".

In order to support the risk sensitive urban development in Sri Lanka, R7 emphasised that "*we should* ***develop overall development plan*** *for urban areas to manage the disaster risks in that area. Otherwise, risk mitigation actions will be failed due to this unplanned urban projects*".

Moreover, R3 emphasised that "*if there is* ***common risk identification checklist or disaster risk list*** *which may affect to the urban development project, it is easy for us to manage the disaster risk when planning an urban development project*".

Under the risk sensitive urban development, R6 stated that awareness about the disaster risk management is essential part when planning an urban development project. Therefore, R6 explained that "*when developing the cities to face the uncertainties arisen due to the disasters, all officers in each level should have the* ***awareness*** *about the disaster risk identification, assessment, mitigation and monitoring processes*".

After identifying the backbone (Figure 4.11) including major activities, a final user story map has been developed by inserting the tasks with reference to each activity. Figure 4.12 illustrates the user story map for User 1.

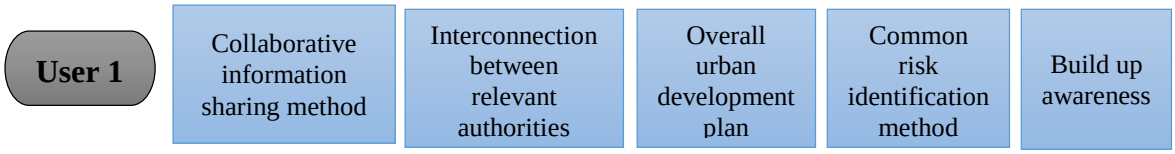


Figure 4.11: Backbone for User 1

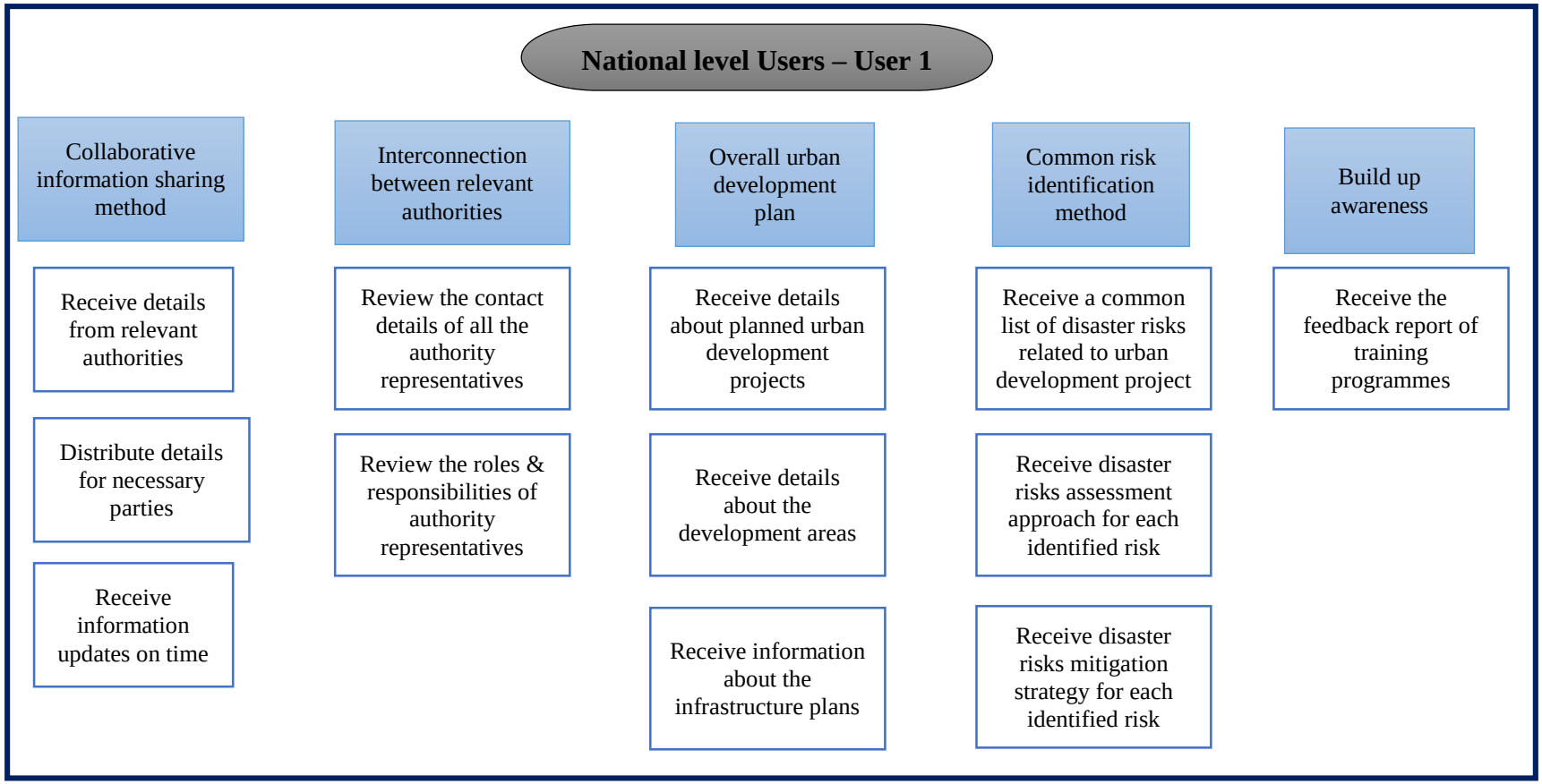


Figure 4.12: User Story Map - User 1

User 2 - Officers in disaster risk management in urban development in Provincial & District level

The backbone was developed from the identified major activities of User 2 as discussed below.

R13 elaborated that provincial and district level officers have the responsibility to **identify the disaster prone areas** within the province and district. The technical information should be gathered from the provincial and district level technical offices such as Provincial UDAs, District National Building Research Organisation (NBRO), District Irrigation Department and so on. Having identified the vulnerable areas, the provincial and district level officers should inform it to other stakeholder levels such as local and community levels to take necessary disaster risk mitigation measures when planning an urban development project.

Under the risk sensitive urban development process, risk identification, assessment, mitigation and monitoring of provincial and district level urban development projects are conducted by the provincial and district level officers related to disaster risk management and urban development. Therefore, they need to **communicate** with officers from other relevant parties and also with the officers at local level authorities. R12 expressed that "*the close connection between the disaster risk management authorities and urban development authorities enhances the effectiveness of risk sensitive urban development context in Sri Lanka*".

Moreover, R17 declared that proper record keeping is an essential method when minimising the disaster risks related to urban development project. As per R17, multiple information is received from external parties as well, therefore, it would be beneficial to **keep records** about the received details, which are very useful for future urban development planning. Therefore, the records related to vulnerable areas, previous disaster details, previous disaster preparedness plans, and vulnerable people details are useful when planning future urban projects.

R14 also highlighted that "***awareness*** *about the disaster risk management and disaster preparedness is essential when planning an urban development project*". Therefore, to risk sensitive urban development in Sri Lanka, all the parties should have a better understanding about the disaster risk management when planning and initiating new developments.

Accordingly, Figure 4.13 illustrates the backbone for User 2 and Figure 4.14 shows the user story map of User 2.

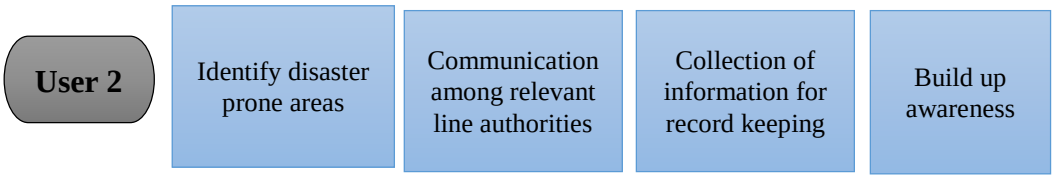


Figure 4.13: Backbone for User 2

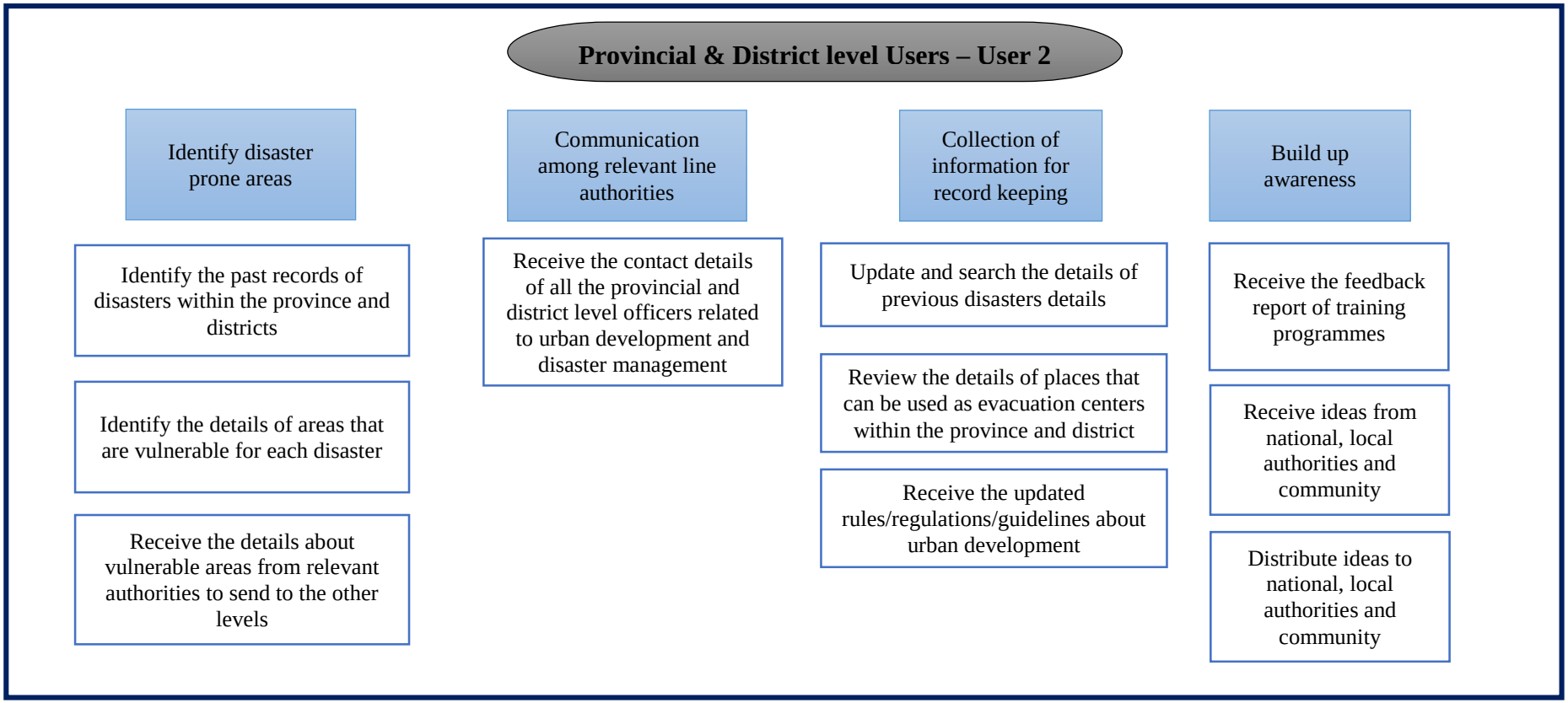


Figure 4.14: User Story Map - User 2

User 3 - Officers in disaster risk management in urban development in Local level

The backbone was developed from the identified major activities of User 3 as shown below.

As per the opinions of the respondents most of the requirements are same as in the provincial and district level users. Accordingly, R16 expressed that "*we should clearly **identify the local vulnerable areas** when we are planning new urban development projects in local level*". Moreover, R18 highlighted that **linkage between the national, provincial, district and community level stakeholders** is needed to develop local level land use maps which may be useful when go for a risk sensitive urban development in Sri Lanka. Not only that the **communication among the relevant authorities** and **proper record keeping** also highlighted by the local level respondents when they are planning risk sensitive urban development.

Moreover, R15 further stated that when considering the enhancement of **awareness**, local level officers have a higher responsibility than other level officers for the coordination and planning of the awareness programmes. Accordingly, the backbone for User 3 is developed as following Figure 4.15 and user story map of user 3 has shown in Figure 4.16.

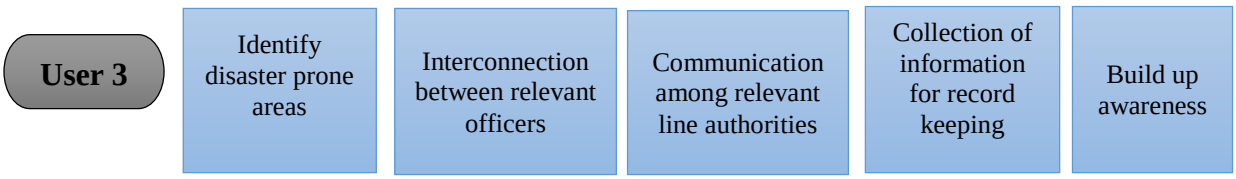


Figure 4.15: Backbone for User 3

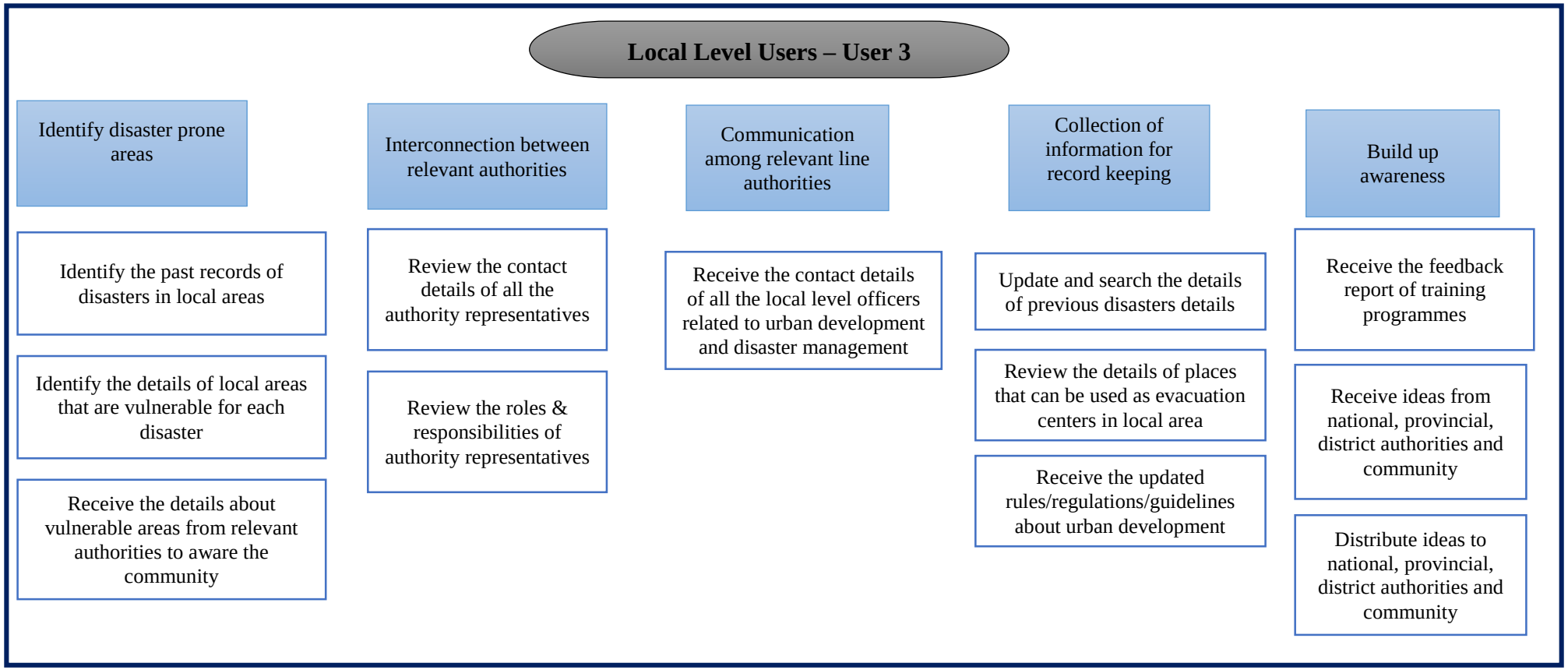


Figure 4.16: User Story Map - User 3

User 4 - Community Level

Community level users are also an important part in risk sensitive urban development since they are the users who experienced and affected by the disasters. As per the respondents under the community level also provided the same opinions as in the local level users, their requirements also analysed as below.

In order to face the uncertainties arisen due to the disasters, **disaster prone area identification** is a major activity. However, the role of a community level in this aspect is different from the role of the other authorities who are related to risk sensitive urban development. As explained by R19, they only need to review the details of vulnerable areas instead of data collection and recording.

The other required activities are same as local level users and R20 also highlighted the importance of **communication** with relevant authorities related to urban development and disaster risk management in Sri Lanka. Further, R19 revealed that with regard to **information management**, the community needs to have the details of the previous disasters, disaster preparedness approaches, disaster resilient development methods etc. Similarly, **awareness** about the risk sensitive urban development approaches is the other major activity required by the community level users. Figure 4.17 illustrates the backbone of User 4 and Figure 4.18 shows the user story map of user 4.

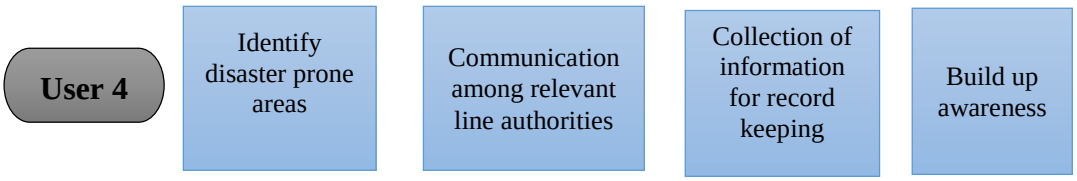


Figure 4.17: Backbone for User 4

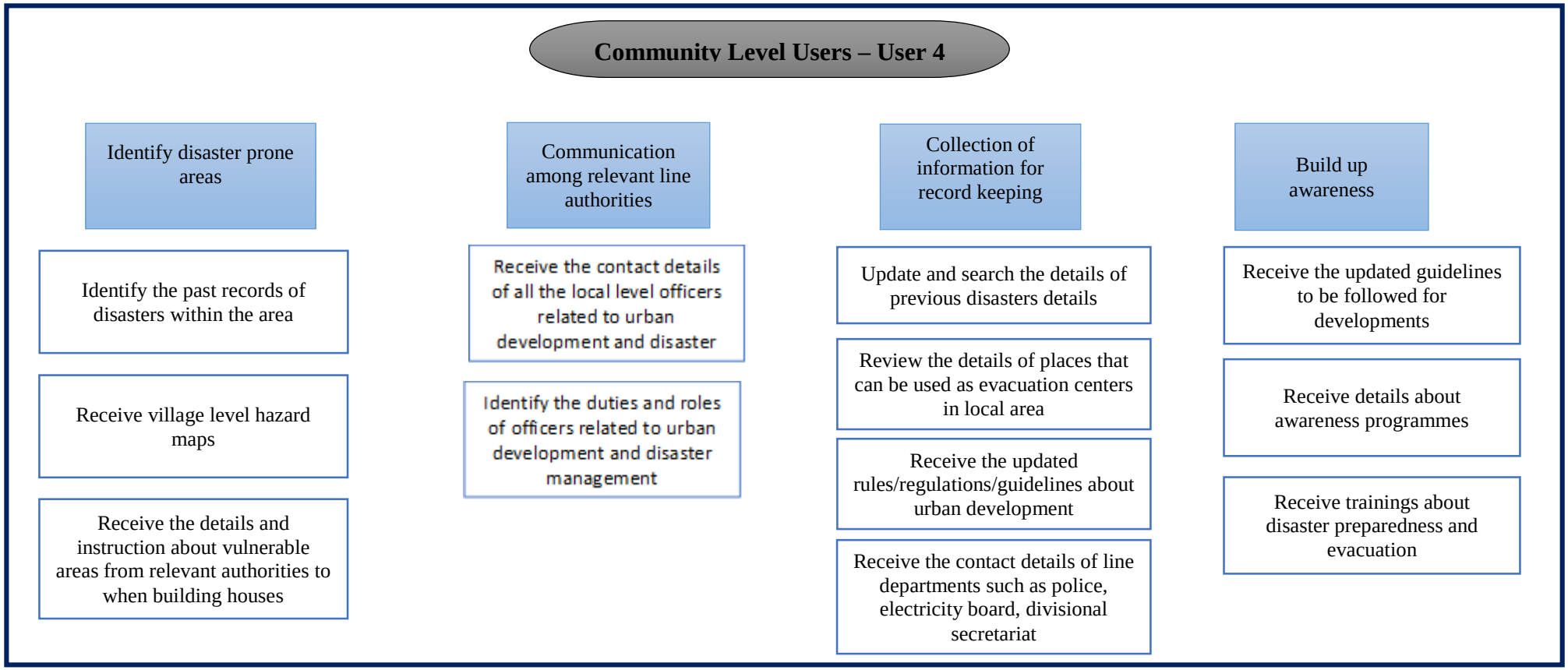


Figure 4.18: User Story Map - User 4

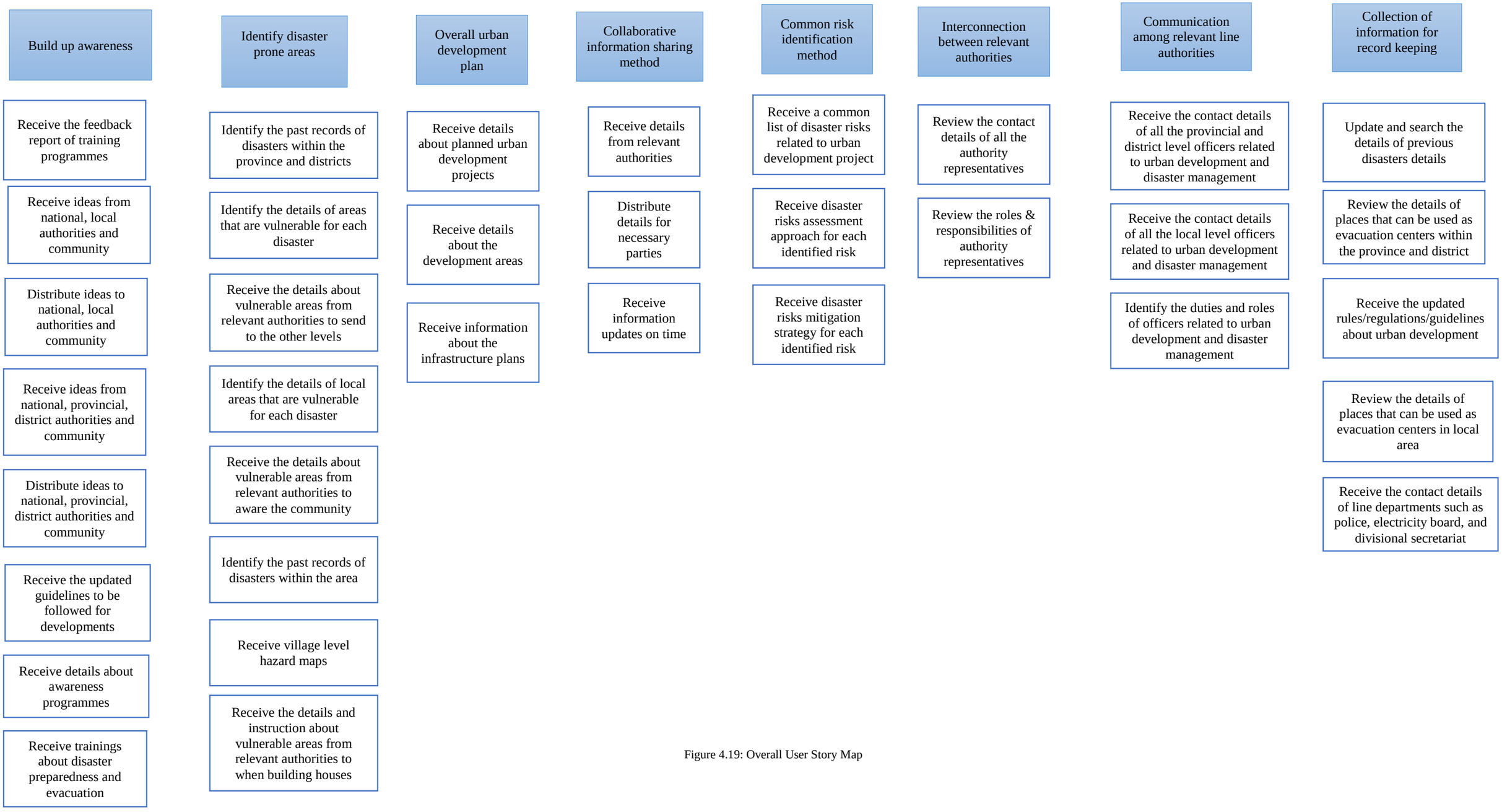


Figure 4.19: Overall User Story Map

After reviewing all the users' requirements on risk sensitive urban development, the overall user story map has prepared by integrating all the user stories (Figure 4.19) into a single map. The final user story map considers all the users of the project and the requirements were placed in a well-organised manner. The overall map has been presented for the prioritisation with the summarised user stories.

4.2.2.2 Prioritisation of User Requirements using Focus Group Discussion

The user story prioritisation has been conducted through a focus group discussion. The participants were chosen to represent a mixed range of expertise in urban development and disaster risk management. The participant details of the focus group discussion are presented in Table 4.9.

Table 4.9: Participant Profile - Focus group discussion

Participant Code	Participant Description	Expertise
FG1	Officer who is related to urban development planning	24 years' experience in urban development planning
FG2	Officer who is related to disaster risk management	16 years' experience in disaster risk management
FG3	Officer who is related to disaster risk management in urban projects	11 years' experience in disaster risk management in urban projects

Initially, the background of the study has been introduced to the participants by the facilitator and participants were asked to present their opinions about the study. FG1 stated that "*it is good suggestion for developing a supportive framework for risk sensitive urban development because most of the officers also do not have a clear idea about risk sensitive urban development approaches*". Adding to that comment, FG2 declared that in order to face the future disasters with minimum effects to the people and environment, urban developers should be given more priority on risk sensitive urban development approaches. Moreover, FG3 highlighted that due to the climate

change condition in Sri Lanka, especially risk sensitive urban development approaches are needed to follow. Therefore, the group agreed to the development of risk sensitive urban development framework which is contextualised to Sri Lanka.

The developed user story map which is illustrated in Figure 4.19 was then presented to the participants and asked them to categorise the user stories under ‘MoSCoW’ concept. The final output for the user story prioritisation that is obtained from the discussion is presented in Figure 4.20.

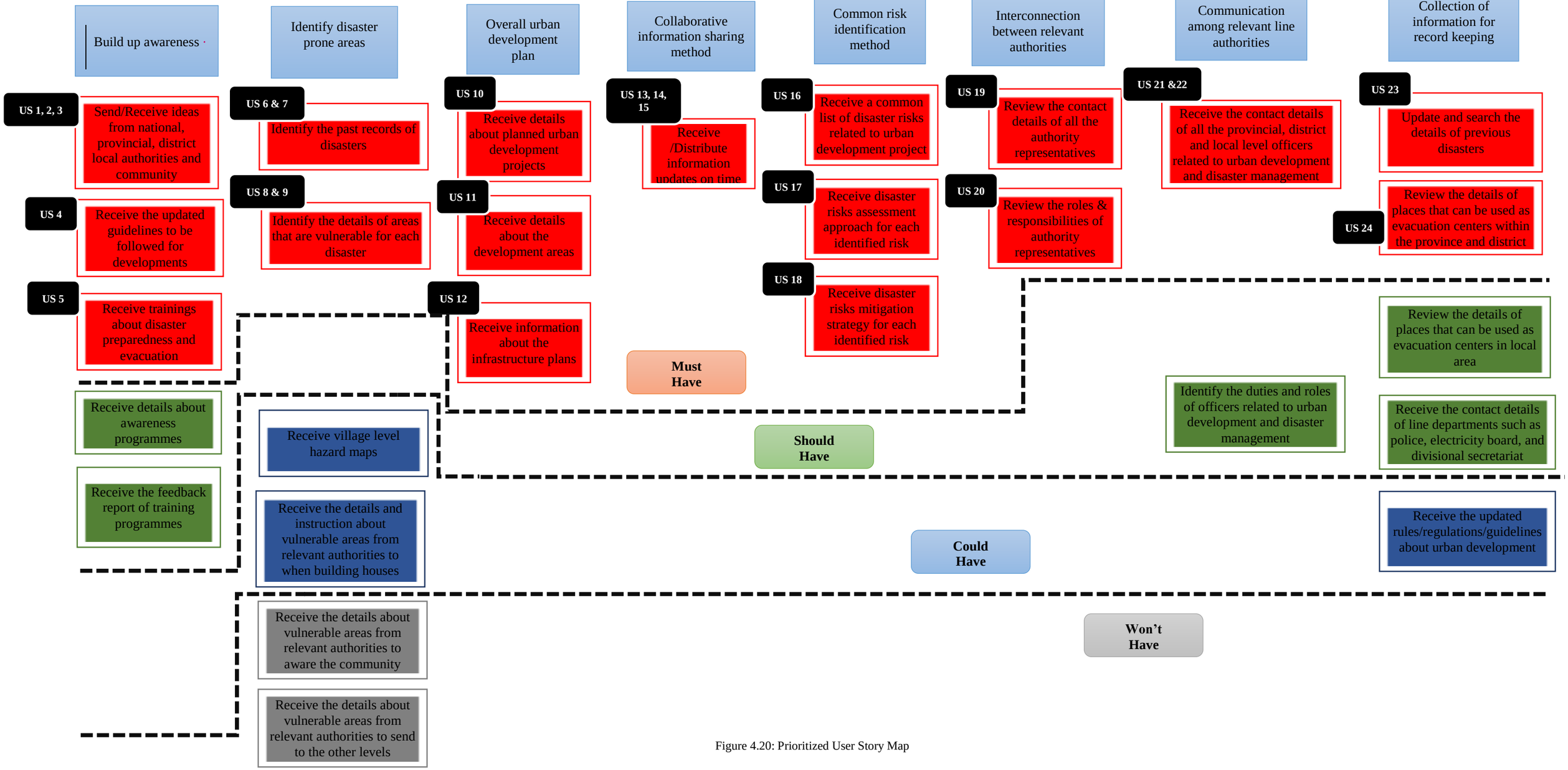


Figure 4.20: Prioritized User Story Map

As per Figure 4.20, the prioritisation of user stories by the participants was based upon the following headings of backbone.

Build up awareness

All the participants have identified the importance of awareness among the officers and community related to urban development and disaster management. They have stated that disaster risk management procedures should be aware by urban developers in order to plan risk sensitive urban development. Accordingly, send/receive ideas about risk sensitive urban development among the national, provincial, district, local level authorities and community, received updated guidelines to be followed and receive training about disaster preparedness and evacuation have been considered under "must have" category requirements. FG3 highlighted that "*awareness about the updated development guidelines is essential thing when we planning risk sensitive urban development. If the community level do not have an idea about the guidelines, it will caused to fail the total procedures*".

Identify disaster prone areas

At the very first, FG1 has highlighted that identifying the hazard prone area is of the utmost importance when it comes to risk sensitive urban planning. FG1 further stated that that "we should identify and develop hazard maps before planning urban developments". Supporting to FG1, FG3 further expressed that after identifying the disaster prone areas, developers should have the proper strategies to avoid or mitigate the disaster risks expected to affect the planned projects. FG2 also agreed with other participants and stated that identifying the past records of disasters and identifying the details of areas vulnerable for each disasters are the main requirements. FG1 said that "since those two major requirements cover the village area hazard identification also, there is no higher requirement to consider about receiving village level hazard maps and receiving the details and instruction about vulnerable areas from relevant authorities to when building houses. Furthermore, they have elaborated that since other remaining requirements are considered under the awareness activity, there is no

requirement to consider receiving the details about vulnerable areas from relevant authorities to aware the community and receiving the details about vulnerable areas from relevant authorities send the other levels.

Overall urban development plan

All the participants were highlighted the requirement of overall development plan for each and every cities in Sri Lanka. FG1 revealed that, "*still Sri Lanka has not any agreed overall development plan and it is the major weakness that I have noticed in Sri Lankan urban development process*". Adding to that, FG3 also expressed that due to the absence of overall development plan, it will cause to generate and increase the disaster risk because of the unplanned urbanisation. Therefore, all the participants agreed to consider all the requirements coming under overall development as "must have" requirements to be fulfilled for risk sensitive urban development in Sri Lanka.

Collaborative information sharing method

During the discussion, another thing that was highlighted by all the participants is to have collaborative information sharing methods for all the parties related to urban development and disaster risk management. Under that topic, FG1 declared that "*Before planning the development, generally we take information from NBRO, Irrigation, SLLDC, DMC and other relevant authorities related to urban planning, but when it comes to the provincial, district, local and community levels, there is no any method for information distribution due to the sharing issues*". Adding to that statement, FG3 elaborated that "*As an engineer in SLLDC, we give all the guidelines, plans and strategies to the developers, however, they have not known about the details due to the absence of proper information sharing method. Therefore, I highly recommend to build an easy and user friendly information sharing method related in Sri Lanka*". FG2 also agreed to both of the opinions and they have considered all the requirements as "must have" requirements under the risk sensitive urban development.

Common risk identification method

All the participants have highlighted the importance of having a common risk identification method for urban development in Sri Lanka. FG1 pinpointed that there should be list of disaster risks related to urban development projects in Sri Lanka during the pre- design stage of the project. FG1 further explored that "*we should check which disaster risk will be affected to the planned development and which risks are generated due to the planned project. So, I think there should be a common risk identification method for risk sensitive urban development*". FG2 and FG3 also agreed with it and they have decided to concern all the requirements as "must have" requirements under the risk sensitive urban development.

Interconnection between relevant authorities

Interconnection between the authorities related to urban development and disaster management has been also identified as key requirement under the risk sensitive urban development. During the discussion, FG2 explained that "*some officers specially in grama niladari level and community level do not have a connection with relevant authorities. Since that, it caused to increase the unplanned constructions which lead to disasters such as flood and landslides*". FG3 also stated that due to this disconnection, people are less focussing to the risk resilient built approaches and they always neglect follow the development guidelines. Therefore, all the participants agreed to consider all the requirements coming under this area as essential requirements in risk sensitive urban development.

Communication among relevant line authorities

Under the topic of communication among the relevant line authorities, participants have highlighted the importance of having the communication among the relevant line authorities when planning a risk resilient urban development project. Accordingly, FG1 emphasised the requirement of the internal staff communication when planning projects. Further, FG1 elaborated that communication among the provincial and local level authorities also needed during the urban development planning and therefore all

the participants agreed that receiving the contact details of all the provincial, district and local level officers' related to urban development and disaster management is essential for risk sensitive urban development. However, identification of duties and roles of officers related to urban development and disaster management is not highly needed under this area and it covers under the previous requirement.

Collection of information for record keeping

All the participants discussed this as another important set of requirements. However, FG2 explained that 'updating the details of previous disasters and evacuation areas' should be kept in 'Must Have' category while 'updating the contact details of line departments and other authorities such as police, electricity board, and divisional secretariat details' should be shifted to the 'Should Have' category, since risk sensitive urban development planning approach. However, FG2 expressed that in the risk sensitive urban development viewpoint all these user stories follow a similar repetitive method and therefore including all those details wouldn't be a matter. However, participants agreed to categorise the 'updating rules/regulations/guidelines about urban development details' under the 'Could Have' group. FG1 and FG2 explained this has been covered from previous requirements and there is no need to include under this area.

4.3 Framework to Support Risk Sensitive Urban Development in Sri Lanka

As per the results of user story prioritisation in Section 4.2.2.2, 'Must Have' user stories have been considered when designing the framework to support risk sensitive urban development in Sri Lanka. Accordingly, empirical findings analysed the process used in disaster management in urban development projects, weaknesses of the current process and user's requirements on risk sensitive urban development are summarised through the framework and it provides a risk sensitive urban development approach for Sri Lanka. Figure 4.21 illustrates the designed framework which is to support risk sensitive urban development in Sri Lanka.

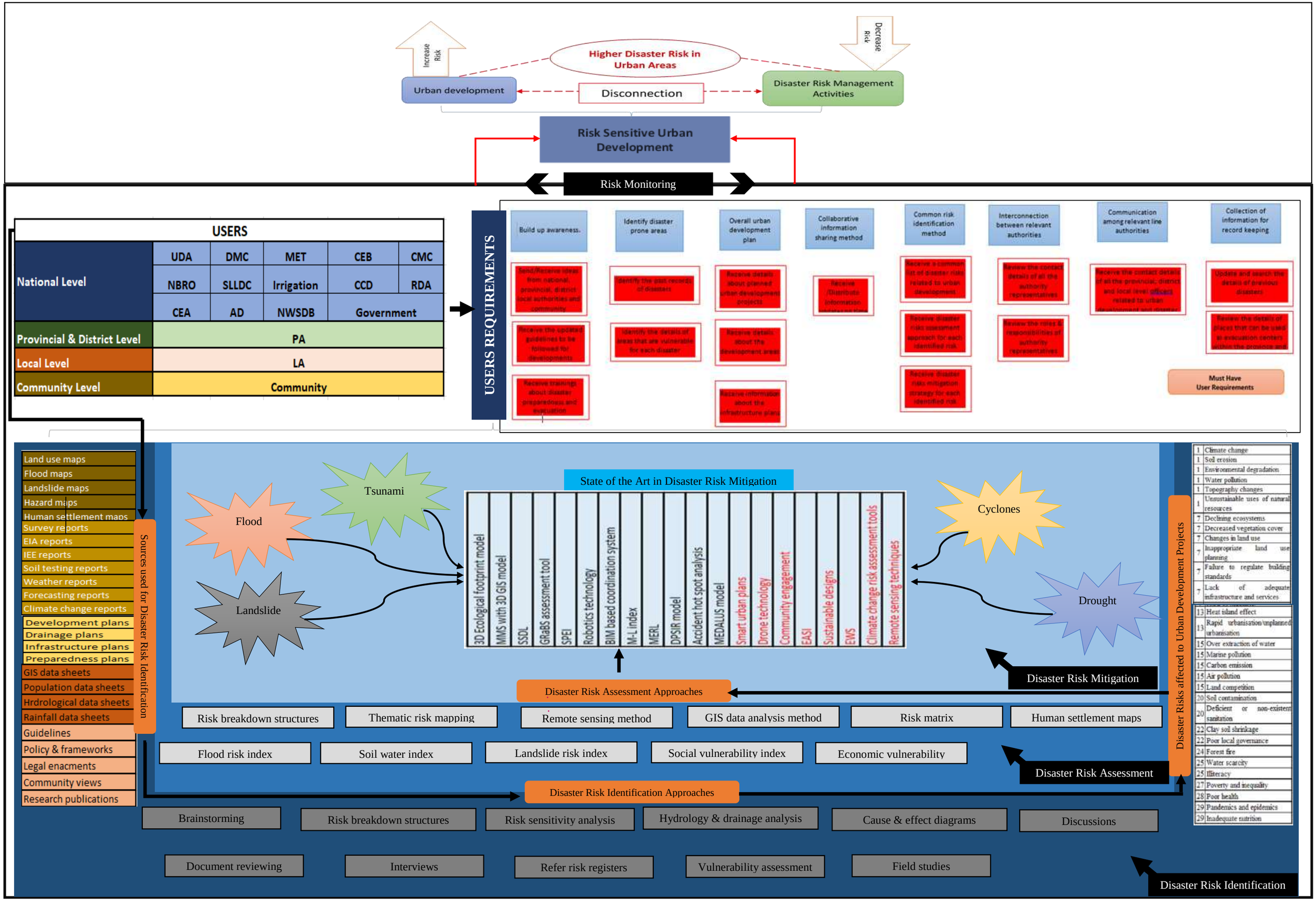


Figure 4.21: Framework to Support Risk Sensitive Urban Development in Sri Lanka

Legend 1 - Abbreviations used in the framework

UDA	Urban Development Authority
Met	Meteorology Department
CEA	Central Environmental Authority
NBRO	National Building Research Organisation
SLLDC	Sri Lanka Land Development Corporation
AD	Agriculture Department
DMC	Disaster Management Centre
Irrigation	Irrigation Department
CCD	Coastal Conservation Department
CMC	Colombo Municipal Council
RDA	Road Development Authority
CEB	Ceylon Electricity Board
NWSDB	National Water Supply and Drainage Board
PA	Provincial Authorities
DA	District Authorities
LA	Local Authorities
GIS	Geographical Information System
SSDL	Storm Surge Disaster Loss
SPEI	Standardised Precipitation-Evapotranspiration Index
MMS	Mobile Mapping System
M-L	Malmquist -Luenberger
BIM	Building Information Modelling
EASI	Environmentally Sensitive Areas Index
MERL	Marine Ecological Red Line
EWS	Early warning system
DPSIR	Driving-Pressure-State-Influence-Response
MEDALUS	Mediterranean Desertification and Land Use

Legend 2 - Approaches used in the framework

Approach	Description
3D Ecological Foot Print Model	3D Ecological footprint model has been developed to measure natural capital utilisation pattern which directly affects the urban environment. The model has three dimensions such as Ecological Carrying Capacity Intensity (EC intensity), Ecological footprint depth (EF depth) and Partial Least Squares (PLS) model. EC intensity was calculated to optimize the accounting of ecological carrying capacity (EC) and EF depth and EC intensity were quantitatively investigated and influencing factors were further explored based on a partial least squares (PLS) model. The findings of the above mentioned 3D model could provide guidance for urban development.
M-Lindex	M-L index has been developed to analyse the changes in efficiency and the impact of technological innovation on environment, and give policy recommendations to save environment.
MMS with 3D GIS Model	3D Geographical Information System (GIS) support urban planners and consumers to improve their spatial perception and awareness of urban areas.
ESAI	Environmentally Sensitive Areas Index (ESAI) was developed to identify areas vulnerable to the threat of desertification. Variables and thematic indicators such as climate, soil quality, land use, amount of plant cover and management are included in the ESAI.
SSDL	Storm surge is one of the most severe marine disasters in the world and it is affecting the whole coastal area. Therefore, to prevent from storm surge disasters, estimating the storm surge disaster loss (SSDL) is very useful and it will support the risk sensitive urban development process. When estimating the storm surge loss, hazards of the project, disaster causing factors, the vulnerability and resilience of disaster bearing bodies are considered. Accordingly, when planning an urban development project, the estimation of SSDL is beneficial as it provides a basis to make the decisions about project.
MERL	Coastal marine ecosystems are sensitive to anthropogenic stressors and environmental change. The Chinese Government proposed an ecosystem-based marine spatial planning scheme called the "Marine Ecological Red Line" (MERL), which aimed at protecting ecologically sensitive areas. The assessment and mapping of ecosystem sensitivity

	provide important tools for regional MERL and setting conservation priorities. This model provides details to decide which area is suitable to develop an urban development project. It gives an operational approach to provide relevant scientific knowledge on the process of ecosystem-based marine spatial planning, and facilitates policy-making decisions in marine management with risk sensitive urban development.
GRaBS	GRaBS has been developed as a collaborative, innovative, cost effective and a user friendly assessment tool to highlight the climate change risks and vulnerabilities in urban areas in order to aid the strategic planning and delivery of climate change adaptation responses.
Sustainable design	Urban designs that consider regional climatic conditions are one of the most important approaches in risk sensitive urban development. The design of the urban development should be developed by considering the climatic conditions of the area.
SPEI	This index is explained about the impact of climate change on Land degradation and desertification (LDD) by detecting the temporal oscillations in drought in the context of climate change, and it is therefore a reliable climate parameter for this method. At present, LDD is one of the greatest environmental challenges caused by climate change resulting mainly from anthropogenic activities. SPEI is pointing to a link between not only environmental sensitive areas and climate change, but also the impact of other factors, such as vegetation, topography and soil. Therefore, the details received from SPEI is valuable for the risk sensitive urban development.
EWS	In order to face the uncertainties that arise from climate-induced disaster risks there is an urgent need of early warnings system. Through this system, people can be aware about the risk and prevent the risk before it leads to a disaster. As such, early warning system is a beneficial approach, for the risk sensitive urban development.
Smart urban plans	Smart urban planning is an innovative method of risk sensitive urban development since it is planned to develop all the urban facilities by considering the environmental aspects.
DPSIR Model	Driving-Pressure-State-Influence-Response (DPSIR) model is based on environmental early warning system which combines three aspects such as ecology, resources, and environment. DPSIR model also includes human activities, stress, and environmental state, impacts on ecosystems, human health, and political responses. First, the DPSIR model covers important elements of economy, society, resources, and

	environment, which can clearly and simply reflect the relationship between the environment and other factors, thus it can provide a scientific theoretical basis for policymakers. Secondly, it not only indicates the influence of society, economic development, and human behaviour on the consumption of resources and ecological environment, but also shows the feedback of human behaviour and its final lead to the state of resources and environment, which makes the whole system a cycle. Thirdly, it provides a basic framework for the construction of the environmental index system which is suitable for early warnings and the assessment of the environment. Lastly, its evaluation process is relatively easy to operate and use, which brings convenience to scientific researchers. Therefore, when countries go for a risk sensitive urban development this model will be very useful in minimising the risk of urban areas.
Drone Technology	Drone technology is one of the artificial intelligence method and it is used to forecast disasters and provide support throughout catastrophes.
Climate change risk assessment tools	Assessment of climate change risks and vulnerability is essential in order to inform and implement appropriate adaptation strategies. Assessment of climate change risk helps to improve the resilience of urban areas since, it is provided information to develop strategies to reduce future risks associated with climate change impacts. There are several climate change risk assessment tools such as decision making frameworks, portals or platforms and screening models. These tools are used to manipulate and visualise the general risk or impact of the climate change.
Community engagement	Community views have been identified as one of the major approaches that can be used when planning an urban development project. Community is the party who is facing the risk of urban development projects and their views and suggestions will be very useful to reduce such risks to create a risk sensitive urban development project.
Remote Sensing Techniques	Remote sensing technology is used to calculate the Salinized Land Degradation Index (SDI). By using this remote sensing technology, SDI calculates the Salinization Index (SI), Normalized Difference Vegetation Index (NDVI) and Land Surface Soil Moisture Index (LSM) at once. The combination of the aforementioned indicators can provide a comprehensive understanding of land degradation in salinized areas for the reference of regional land management.

Robotics Technology	Robots have used to travel deep into disaster zones to inspect destruction and bring help. Robotic technology provides the details, photos, videos, and other data about the disaster zones and then uses that data to predict outcomes in previously unknown circumstances.
Accident Hot Spot Analysis	Under this analysis, it identifies the accident-prone location and assessing the pattern of accidents. Generally, estimation of accidents and unsafe conditions were determined with the help of this analysis and it helps to predict the pattern of accidents. Through this accident hot spot analysis approach, developers can plan the urban developments while assisting to prevent and reduce accidents.
BIM based coordination support system	In recent years, the increasing implementation of building information modelling (BIM) in the architecture, engineering, and construction (AEC) industries is changing the way emergency response can be approached. A BIM model is a digital representation of all of the aforementioned physical and functional characteristics of a building throughout its entire lifecycle. BIM supports to coordinate people such as fire-fighters, commanders, and planners in emergency response scenarios with stable performance.
MEDALUS model	Mediterranean Desertification and Land Use (MEDALUS) model is one of the most widely used approaches to assess desertification risk in a development. This MEDALUS model mainly focuses five main indicators including soil, groundwater, vegetation cover, climate, and erosion were selected for estimating the environmental sensitivity to desertification.

The framework to support risk sensitive urban development in Sri Lanka (Figure 4.21) has been designed based upon the data analysed under the disaster risk management process used in Sri Lankan urban development projects and the analysis of user requirements on risk sensitive urban development.

As per the framework, disaster risk management process has comprised with four main steps; disaster risk identification, disaster risk assessment, disaster risk mitigation and monitoring. The three layers shown in blue colour shades show the approaches that are used for identification, assessment and mitigation. Under the risk identification layer, it depicts the disaster risk identification process that can be used when planning an

urban development project in Sri Lanka. As per the framework, disaster risks, which have been ranked according to the level of importance, sources that are used for identification of disaster risks, and the approaches used for disaster risk identification are shown under risk identification layer. Middle layer of the framework represents the disaster risk assessment approaches used to assess the disaster risks and third layer presents the disaster risk mitigation approaches identified under the state of the art in risk sensitive urban development. The approaches used in Sri Lankan urban development projects have been shown in red colour text. The risk monitoring is considered as an umbrella activity which should influence the other three steps of disaster risk management process, hence placed at the top of the framework.

The stakeholders, who are categorised under four levels such as national, provincial & district, local and community levels, are differentiated using colour coding. In addition, the user requirement obtained to improve the risk-sensitive urban development are presented along with the stakeholders. Only the requirements that are prioritised as 'must-have' are incorporated in the framework. According to the user's requirements on risk sensitive urban development, the framework has been designed as a supportive approach. Therefore, it is necessary for the users of this framework to consult the user requirements in order to make the risk-sensitive urban development projects more effective.

All in all, the user of this framework can get an insight on the risk sensitive urban development process in terms of the disaster risks in Sri Lanka; approaches used for risk identification, assessment and mitigation; the sources available for the risks identification; the stakeholders involved with risk-sensitive urban development; and the prioritised user requirements to improve the risks-sensitive urban development. As such this framework will be beneficial for any stakeholders who want to develop urban project as risk sensitive to disaster risks. The framework intends to strengthen the collaboration between the stakeholders from urban development and disaster management sectors.

As such, this framework can be used as a supportive tool of risk sensitive urban development, and it supports all the stakeholders who are involved with urban development and disaster management in Sri Lanka.

4.4 Framework Validation

Framework validation has been conducted through expert interviews. The participants were selected to represent a broad range of expertise in risk sensitive urban development and Table 4.10 presents the respondent's profile of expert interviews.

Table 4.10: Respondent's Profile of Expert Interviews

Participant Code	Participant Description	Expertise
E1	Officer who is related to urban development planning	24 years' experience in urban development planning
E2	Officer who is related to disaster risk management	16 years' experience in disaster risk management and urban development

The framework (Figure 4.21) has been presented to both the experts (E1 and E2) to highlight the strengths and weaknesses of the designed framework. Since, both participants have involved with focus group discussion, they had a clear idea about the study. Also, E1 and E2 have worked under urban development planning division and they have involved with disaster management authorities as well. Hence, they have knowledge and experiences about the risk sensitive urban development approaches. During the interview, both experts commented that the developed framework will be very useful for urban developers in national level to community level. However, E2 suggested that "*it is good, if the framework can elaborate the definitions about the strategies shown in the disaster risk mitigation layer*" and suggested to add it to the legend area. Accordingly, as supplementary to the framework, 2 legends were added to explain the abbreviations and the definitions of the risk mitigation measures used on the framework.

4.5 Discussion

As described in the literature review chapter, risk management process is consisted four steps such as risk identification, risk assessment, risk mitigation and risk monitoring. Accordingly, the data collected from interviews also analysed under those four steps. During the risk identification stage, Wanner (2019) has explored few risk identification methods such as document analysis & historical diagrams, evaluation of risk lists, lessons learned from similar projects, brainstorming with the project team & experts, interviews with professionals & other project managers, and risk checklists. Under the Sri Lankan context, empirical findings have been revealed further risk identification methods and risk identification sources. Risk identification sources are categorised based on the authorities involved to urban development and disaster management in Sri Lanka. Moreover, the narrative literature review has explored thirty types of disaster risks that can affect to the urban development projects as per the classification (environment or climate related, urban development related, social related and governance related risks) presented by Organisation for Economic Cooperation and Development (2012). According to the literature review, most of the disaster risks are generated related to climate and environment category and it has been proved from the empirical findings also. Project has identified four main stages of urban development process such as pre-design stage, design and development stage, use or management stage and the demolition stage and disaster risks were classified under those stages. Majority of the disaster risks were classified under the pre-design stage and empirical findings also confirmed it.

Under the risk assessment and quantifying, several approaches have been identified in current context and those have been divided as quantitative approaches and qualitative approaches. Moreover, empirical findings revealed that less focus and the absence of the exact risk assessment approach affect to the efficiency in risk assessment. Dickson et al. (2012) has also confirmed the importance of risk assessment to help urban development projects for the identification of hazard-prone areas, basic climate change challenges, and capacity for disaster preparedness and response. Eventhough, Jones &

Preston (2011); EMI (2006); Zerbo et al. (2020) have identified four basic approaches under the risks management decisions such as elimination, mitigation, transfer and retain the risk. However, Dickson et al. (2012) have emphasised that risk mitigation is the best solution to manage the risks related to urban development projects. According to the findings of interviews, risk mitigation strategies were identified under each critical disasters faced in Sri Lanka. Moreover, empirical findings revealed that technological strategies are limitedly used and given more focus for theoretical strategies in Sri Lankan urban development projects and Bello et al. (2021) stated that technical facilities are very the most required strategy that can be used for disaster risk mitigation. Under the risk monitoring stage, empirical findings revealed that there is no exact risk monitoring method in Sri Lankan urban development projects to keep the implemented risk mitigation actions effectively. Siriwardana et al. (2018a) also confirmed that less monitoring has caused to fail the implemented risks management strategies and elaborated the importance of risk monitoring for successful disaster management in Sri Lankan urban development projects.

Jayasena, Waidyasekara, Mallawarachchi, and Peiris (2021) have emphasised the users involved in urban development and Institute of Policy Studies (2016) elaborated the users related to disaster management. Accordingly, those stakeholders were interviewed and more participants were identified during the interviews. Under the stakeholders of risk sensitive urban development, empirical findings highlighted that coordination among the stakeholders related to urban development and disaster management should be improved to achieve effective risk sensitive urban development in Sri Lanka. Moreover, lack of coordination among the stakeholders involved to risk sensitive urban development was highlighted by Roslan et al. (2021) and Institute of Policy Studies (2016) emphasised the importance of the stakeholder collaboration for effective risk sensitive urban development. Furthermore, the strengths and weaknesses of disaster management in Sri Lankan urban development projects have been explored and available expertise knowledge, risk management guidelines, early warning systems and forecasting methods were appreciated under the interviews. Among those strengths, expertise knowledge has been highlighted as a key factor for assisting

disaster management (UNDP, 2010; Republic of Palau, 2016). Less awareness and coordination among the local level development authorities, absence of information sharing method, absence of the overall development plan, less monitoring and negative attitudes about the disaster management have been identified as weaknesses in the urban development process and those weaknesses has increased the disaster risk. Ding et al. (2019); Dilanthi Amaratunga and Haigh (2020); Jiang, Tian, & Zheng (2018); Lee and Lin (2022) have also emphasised the mentioned weaknesses and strategies were proposed to overcome the weaknesses. Accordingly, development of collaborative information sharing method, enhancing the awareness & positive attitudes to manage disaster risk were proposed as strategies. Moreover, to achieve an effective risk sensitive urban development approach in Sri Lanka, users were interviewed to capture their requirements. Under that, build up awareness, disaster prone area identification, overall development plan, collaborative information sharing method, collaboration and communication between the authorities were highlighted in the empirical findings. Thereafter, the framework (refer Figure 4.21) was developed to support risk sensitive urban development approach in Sri Lanka.

4.6 Chapter Summary

This chapter presented the analysis of data that were collected through semi structured interviews and focus group discussion. The current process in disaster risk management in Sri Lankan urban development projects were analysed through the findings collected from the stakeholders who are related to urban development and disaster risk management in Sri Lanka. Further, the user requirements to support risk sensitive urban development in Sri Lanka have been identified. The user requirements were presented in user story maps. The user stories were prioritised in order to identify the most important user stories that need to be adopted in risk sensitive urban development based upon the data analysis of the focus group discussion. Afterwards, the framework has been developed and validated by conducting expert interviews.

CHAPTER 5

5.0 CONCLUSIONS AND RECOMENDATIONS

5.1 Introduction

This chapter discussed the final conclusions based on the achievement of objectives through the literature review, data analysis and discussion in the preceding chapters. Further, the contribution of the research to the knowledge and recommendations to encourage the risk sensitive urban development approach in Sri Lanka have been proposed and further research areas have been suggested to expand the study.

5.2 Accomplishment of Research Aim and Objectives

In order to achieve the aim of developing a framework to support risk-sensitive urban development in Sri Lanka, four main objectives were achieved and discussed in below sub sections.

5.2.1 Objective 1: To review the state of the art in risk sensitive urban development

First objective of the study identified the state of the art in risk sensitive urban development and it was covered by systematic literature review. Through the systematic literature review, globally used twenty (20) approaches were identified under the state of the art in risk sensitive urban development and categorised as highly used, moderately used and limitedly used approaches. Accordingly, 3D ecological foot print model, Malmquist -Luenberger (M-L) index, Mobile Mapping System (MMS) with 3D GIS Model, Environmentally Sensitive Areas Index (ESAI), Storm Surge Disaster Loss (SSDL), Marine Ecological Red Line (MERL), Standardised Precipitation-Evapotranspiration Index (SPEI), Early Warning System (EWS), Driving-Pressure-State-Influence-Response (DPSIR) Model, Sustainable design, Climate change risk assessment tools, GRaBS assessment tool, Community engagement, smart urban plans, drone technology, remote sensing techniques, robotics technology, accident hot spot analysis, BIM based coordination support system, and

Mediterranean Desertification and Land Use (MEDALUS) model have been identified under the risk sensitive urban development approaches used in globally (Refer section 2.12.2). According to literature analysis, 3D Ecological Foot Print Model, Mobile Mapping System (MMS) with 3D GIS Model, Environmentally Sensitive Areas Index (ESAI) and Climate change risk assessment tools have been identified as key approaches that are highly used in managing the disaster risks in urban development (Refer Table 2.11). Moreover, smart urban plans, community engagement, drone technology, early warning system, climate change risk assessment tools, remote sensing techniques, EASI, and sustainable design approaches have been identified under the Sri Lankan context (Refer Table 2.12).

5.2.2 Objective 2: To explore the current process used to identify, assess and manage the disaster risks in urban development projects in Sri Lanka.

Under the objective 2, the study explored the current process used to identify, assess and manage the disaster risks in urban development projects in Sri Lanka. Disaster risk management process has been discussed under four main stages disaster risk identification, disaster risk assessment, disaster risk mitigation and risk monitoring.

Under the disaster risk identification, there were 30 types of disaster risks related to the urban development projects identified from the literature review and contextualised those identified risks to Sri Lankan urban development projects. In order to identify the most important disaster risks affected to the Sri Lankan urban development projects, the identified 30 disaster risks were ranked according to the frequency of the responses (Refer section 4.2.1.1). Furthermore, disaster risk identification tools, sources and techniques (Refer Figure 4.3 and Figure 4.4) were described under each user levels (national, provincial & district, local and community level). Disaster risk assessment approaches were explored under the two categories; qualitative approaches and quantitative approaches (Refer section 4.2.1.2)). In the third step of the disaster risk management, strategies used for disaster risk management in urban development projects were identified under the common disasters affected to Sri Lanka (Refer

section 4.2.1.3). Furthermore, few risk monitoring approaches were derived from the interviews (Refer section 4.2.1.4).

Thereafter, strengths and weaknesses of current disaster risk management process in urban development projects were derived and there were many weaknesses than the strengths. Accordingly, absence of collaborative information sharing method, less awareness about the risk sensitive urban development and absence of overall development plan have been identified as key weaknesses of the current process (Refer section 4.2.1.6). In order to mitigate and overcome the identified weaknesses, several strategies were proposed and risk sensitive urban development approach has been highlighted by the participants (Refer section 4.2.1.7).

5.2.3 Objective 3: To capture the user requirements for an effective risk-sensitive urban development approach in Sri Lanka

The objective 3 was to capture the user requirements for an effective risk-sensitive urban development approach in Sri Lanka. Initially, the user requirements were gathered as user stories separately for each user through semi structured interviews. The users were identified from the literature review and users were categorised as national, provincial & district, local and community levels (Refer section 4.2.1.5). Then, the user story maps were developed for each user separately considering their requirement and thereby final user story map was demonstrated by combining all the user requirements (Refer Figure 4.19). The user story prioritisation has been conducted through a focus group discussion and user stories were categorised as ‘Must Have’, ‘Should Have’, ‘Could Have ‘and ‘Won’t Have’ method (Refer Figure 4.20). Then, the ‘Must Have’ user stories (24 user stories) were used when developing the framework which was designed under objective 4.

5.2.4 Objective 4: To device suitable components from the analysed data for a framework for supporting risk-sensitive urban development in Sri Lanka.

Final objective of the study was to develop a framework for supporting risk-sensitive urban development in Sri Lanka. Based upon the findings of objective 1, 2 and 3, the framework was designed for supporting risk sensitive urban development in Sri Lanka (Refer Figure 4.21). The designed framework consists of three main layers such as disaster risk identification, disaster risk assessment and disaster risk mitigation. Apart from that risk monitoring is focussed the whole process and it enhances the efficiency of the risk sensitive urban development. Further, the developed framework is addressed the coordination among the authorities related to urban development and disaster management. In addition, the risk sensitive approaches identified from the systematic review has been incorporate with framework with the aiming to update knowledge and share information about the risk sensitive urban development approach. Moreover, the framework presents the captured user requirements for an effective risk sensitive urban development. When considering the aforementioned factors it can be deduced that the developed framework to support risk sensitive urban development is ideal for a successful risk sensitive urban development approach in Sri Lanka and it was confirmed through the framework validation results (Refer section 4.4).

5.3 Recommendations

The recommendations that are suggested to improve the risk sensitive urban development in Sri Lanka are given below.

- Development of awareness about risk sensitive urban development approaches – Due to the lack of awareness about the concept and method of risk sensitive urban development, proper awareness programmes should be conducted with each user levels.
- Increase investments on digitally enhanced systems - As a developing country, there is an insufficient financial allocation for these innovative systems, which

discourages researchers. Therefore, it is recommended to invest more in digitally enhanced systems designed for risk sensitive urban development.

- Development of information and coordination systems - It is recommended that the authorities should pay attention to ensure the effective information sharing at provincial, district, local and community levels since there are many issues with resource insufficiency and network barriers.
- Develop an overall development plan for every urban cities – It is very important to have an overall urban development plan for each urban cities to mitigate the issues arisen due to the unplanned developments.

5.4 Contribution to Knowledge

This study contributed to the knowledge on risk sensitive urban development approach that can be used for urban development projects in Sri Lanka. Framework development is the main contribution to knowledge. To fulfil that the current process of risks management in urban development projects in Sri Lanka was explored. Further user requirement to make the existing process more effective were analysed.

5.5 Limitations of the Study

The aim of this study was to develop a framework to support risk sensitive urban development in Sri Lanka. There are several types of risks such as disaster risk, capital risk, social/cultural risk, economic risk, institutional and policy risk affect to the urban development projects. However, this study was limited to cover the disaster risk when developing the framework.

5.6 Further Research Directions

The following further research directions were proposed to extend the research further.

- Extend the research to identify the barriers related to risk sensitive urban development approach in Sri Lanka.

- Extend the research to develop digital system to enhance the performance of risk sensitive urban development approach in Sri Lanka.
- Explore the most suitable approaches to be used for identification, assessment and mitigation with respect to particular urban development projects.

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APPENDICES

Interview Guideline

SECTION I – GENERAL INFORMATION

1. Name (optional): ……..
2. Designation: ……
3. Experience: ……
4. Organisation type: …….
5. Name of the organisation (optional): ……

SECTION II – DISASTER RISKS IN URBAN DEVELOPMENT PROJECTS

6. The following table shows the disaster risks of urban development project based on the literature review. Please fill the table.

DR Category	Disaster Risks (DR)		Do you currently consider this as a disaster risk in the process of urban development?	If not, do you think it is necessary to consider this risk during urban development ?(reasons)	If yes, in which stage of the Urban Development Process (x)				What are the disasters that you think these risk can lead?
					Pre-Design Stage	Design and Development Stage	Use, Management and Maintenance Stage	Decline and Demolition / Regeneration	
Environmental/Climate related disaster risks	DR01	Climate change							
	DR02	Declining ecosystems							
	DR03	Pandemics and epidemics							
	DR04	Forest fire							
	DR05	Soil erosion							
	DR06	Land contamination							

	DR07	Environmental degradation							
	DR08	Over extraction of water							
	DR09	Clay soil shrinkage							
	DR10	Water pollution							
	DR11	Marine pollution							
	DR12	Topography changes							
	DR13	Carbon emission							
	DR14	Heat island effect							
	DR15	Air pollution							
	DR16	Water scarcity							
Urban development related disaster risks	DR17	Rapid urbanisation							
	DR18	Land competition							
	DR19	Decreased vegetation cover							
	DR20	Changes in land use							
	DR21	Unsustainable uses of natural resources							
	DR22	Inappropriate land use planning							
Economic & Social related disaster risks	DR23	Poverty and inequality							
	DR24	Poor health							
	DR25	Inadequate nutrition							
	DR26	Illiteracy							
	DR27	Deficient or non-existent sanitation							
Institutional governance related disaster risks	DR28	Poor local governance							
	DR29	Failure to regulate building standards							
	DR30	Lack of adequate infrastructure and services							
Any other please (specific)	DR31	.....							
	DR32	.....							

7. What are the approaches that are used in the organization to identify disaster risks in the process of urban development? Do you use any RBS (risk breakdown structure) to identify the risks?
8. What kind of documents or sources that you consult or rely on when identifying the risks?
9. What are the methods (qualitative or quantitative) used to assess the identified risks in terms of its frequency and impact, etc.?
10. What mitigation strategies are developed to manage the risks that are identified?
11. Who are the stakeholders that you collaborate in managing the risks of urban development process?
    - National level
    - Province / District level
    - Local level
12. According to your point of view, what are responsibilities and capacities of below parties to manage the disaster risk in the urban development projects?

Responsible Party	Responsibilities	Capacities
Government		
Urban Development Authority		
Disaster Management Centre		
Private Companies		
Society		

13. How do you monitor and review the disaster risk management process of urban development projects? (for example maintaining a risk register for urban development projects)

14. Please mention the strengths and weaknesses of the current disaster risk management approaches used in urban development projects.

Strengths	**Weaknesses**

15. Please give your suggestions to improve the current disaster risk management approaches in the urban development projects.

SECTION III – CAPTURING USER REQUIREMENTS FOR RISK-SENSITIVE URBAN DEVELOPMENT

"Risk sensitive urban development" is an innovative planning approach that can transform the way cities are built in order to face the uncertainties that arise from climate-induced disaster risks". It links the urban development approaches along with the disaster risk management approaches collaboratively.

16. Briefly explain your job role in current disaster risk management process.
17. What are the tasks and their potential benefits that you are expecting through a risk-sensitive urban development framework with reference to your job role?

Task	Benefits	Other requirements	Acceptance criteria

18. What is your overall opinion about designing a collaborative framework on "Risk sensitive urban development"?