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Factors Affecting the Effectiveness of Flood Resilience Plan for Urban Sustainability of Ratnapura Municipal Council Area

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Abstract

Natural disasters adversely affect urban built-up areas all over the world. Flood is the most destructive natural disaster that affects Ratnapura, the provincial capital of the Sabaragamuwa Province in Sri Lanka. This monsoonal flooding is a prolonged problem that arises mainly due to the overspill of River Kalu and other water bodies connected to the river during heavy rainy seasons. It causes short-term and long-term damages to human lives, properties, the economy, and the environment. Floods cause severe damages to private residential buildings. Hence, the availability of a flood resilience plan is a significant feature of the good governance of the Local Authorities. There are many factors to consider when preparing a flood resilience plan. This study aims to assess the factors affecting the effectiveness of the existing flood resilience plan in the Ratnapura Municipal Council Area. The main data instrument used is a questionnaire survey from residents in the flood-prone area. It assessed the effectiveness of actions taken by the government pre-disaster, during a disaster, and post-disaster. Various factors affecting the flood resilience plan were identified and categorized: community resilience, economic resilience, ecological resilience, emergency readiness and responsiveness, infrastructure resilience, and social and cultural resilience. Findings revealed that the respondents were more satisfied with emergency readiness and responsiveness out of the five main categories. In addition, respondents address the effectiveness of the existing flood resilience plan and its affected factors like community resilience, economic resilience, emergency readiness and responsiveness, infrastructure resilience and social, and cultural resilience. Findings will be helpful for town planners and the Municipal Council of Ratnapura to identify flood resilience strategies through community perspectives to mitigate the flood hazard and propose innovative strategies to achieve urban sustainability and build resilient communities.

Keywords: Sri Lanka, natural disaster, flood resilience plan, effectiveness, post disaster

1.0 INTRODUCTION

Urbanization and urban sprawl affect the urban environment in numerous ways, and this spontaneous urban development induces natural disasters worldwide. Urban floods occur due to natural and artificial phenomena, and it is one of the major disasters that badly affect urban livelihood (Salvadore et al., 2015). More than 2.8 billion people in the world have been affected by floods since the 1990s (Kovacs et al., 2017). As a result of built-up land changes due to the natural conditions, geographical conditions, and human activities created floods during the rainy seasons. Urban sprawl, land-use changes, and land subdivision are some causes of urban floods in the cities (Driessen et al., 2018). Flooding is a severe natural disaster that results in various losses such as a downturn of the economy, social inequalities, loss of human well-being, health problems, and downgrade of ecosystems (European Environment Agency, 2012; Rezende et al., 2019). Rapid urbanization and urban growth in Asia and Africa pose real challenges to flood risk management (Kovacs et al., 2017).

With urbanization, the flood damage levels have increased, but existing structural measures function did not provide adequate protection (Munich Re Group, 2003). The flood risk always affects the livelihood of residents, and governments are responsible for initiating feasible plans to reduce floods. Flood mitigation and adaptation play a significant role in this process. Therefore, implementing adaptive measures with appropriate resilient strategies minimizes negative impacts (European Environment Agency, 2012). Effective flood resilience factors involve social networks, community response capacity, self-organization, learning, education, and enriching adaptive culture. In addition to uplifting public awareness, an accomplishment of flood forecasting and warning, emergency response planning and training, information sharing, and education and communication. Flood insurance, reports in damage and causalities, damage assessment, reconstruction, charity funds, disaster recovery plans, and financial assistance after a flood situation may influence the effectiveness of flood resilience (Batica, 2015). Minimize the causes of flooding and introduce effective resilience measures are new driving approaches for achieving urban sustainability. Similarly, the effectiveness of flood resilience can be assessed in terms of benefits gained from social, economic, environmental, disaster management, and institutional framework to achieve urban sustainability (Grafakos et al., 2016).

However, several scholars have reviewed the issues regarding measurement frameworks and tools available for assessing flood resilience (Cutter et al., 2008; Oddsdóttir et al., 2013).

In Sri Lanka, the National Physical Plan in 2011 anticipates more than 50% of the country's population will be living in declared urban areas by 2030 are affecting the natural disasters, such as floods, landslides, droughts, coastal erosion, cyclones, lightning strikes, epidemics and effects of environmental contamination (Malalgoda et al., 2013). Flood is the main natural disaster in Sri Lanka, primarily affecting the people in built-up areas, reported over many years (Hettiwaththa & Abeygunawardana, 2018).

River flood is a widespread natural disaster in Sri Lanka, and there are four main river basins in the country which are vulnerable to floods. The Kalu River is the second largest river in the country and in the Kalu Ganga (river) basin, which is highly environmentally sensitive; floods affect rural agricultural lands and urban built-up lands Ratnapura Municipal Council (MC) area. Ratnapura is the provincial capital in Sabaragamuwa Province. Monsoonal flooding is a prolonged problem which the residents face. Consequently, the disastrous situation negatively impacts the human and natural setting of the Ratnapura MC Area.

Apart from river floods, human activities such as forest clearings, mining activities, garbage issues, and blockage of drainage systems indirectly cause widespread flooding (Churchill & Hutchinson, 1984; Hettiwaththa & Abeygunawardana, 2018). Flooding creates long-term and short-term effects on human lifestyle, properties, economy, environment, etc. Consequently, disasters negatively impact urban areas (Hettiwaththa & Abeygunawardana, 2018; Malalgoda et al., 2013). The severe flood in Ratnapura reported in May 2003 caused 122 deaths, affected 34,473 families, and inflicted damage of an estimated 11.4 billion Sri Lankan rupees. Therefore, it is vital to convert Ratnapura into a resilient city and strengthen urban sustainability. A practical, resilient city plan would minimize destructive situations to humans and properties while preparing the environment to carry out economic activities without disruptions to achieve sustainable communities (UN-Habitat, 2015). Currently, the residents in Ratnapura have great perseverance to withstand flood conditions with the help of relationships at a community level. However, existing relationships and cognitive distance between government agencies are limited to overcome the long-term resilience in the area (Ahangama et al., 2019). Furthermore, the social repercussions of flood-affected people are not considered in the implementation of flood-adaptive measures in Ratnapura municipality to prevent flood damage (Churchill & Hutchinson, 1984). Therefore, it is essential to identify the factors affecting the effectiveness of current flood resilience to get rid of the negative impacts (Malalgoda et al., 2013).

Ratnapura Municipal Council area has been severely affected by recent flood incidents. The most suitable method for measuring flood risk in Ratnapura is forecasting river water levels, which will indicate future flood risks. However, the responsible parties do not seem to carry out their duties properly and take proactive actions to mitigate potential floods in the future; instead, they depend on flood relief donations (Ahangama et al., 2019). Therefore, there is a requirement to measure the effectiveness in improving local preparedness, saving lives, and providing resources for rehabilitation during the flood disaster in Sri Lanka, especially in Ratnapura (Ahangama et al., 2019). There are many factors considered for measuring the effectiveness of a flood resilience plan. This study aims to identify the factors affecting the effectiveness of the flood resilience plan for urban sustainability in the Ratnapura Municipal Council Area. In addition, it focuses on identifying the relationship of each main factor with the flood resilience plan.

2.0 LITERATURE REVIEW

2.1 Urban Development and Urban Sustainability

Currently, most urban areas of all over the world face flood risk. Flooding is a risk-related phenomenon influenced by natural conditions, undeveloped disaster culture of urban communities, etc. Therefore, future urban expansion needs to focus on a broad view of flood risk and new forms of flood damage. At Present, 55% of the world's population lives in urban areas, which is expected to increase to 68% by 2050 (United Nations, n.d.). However, the increase in urban agglomeration areas, population, buildings, and infrastructure highlights a more vulnerable society in the future due to climate-induced hydro-hazards (Jahn, 2015).

The excessive urban development throughout the last century has deteriorated the natural flood protection systems in three ways. Firstly, built-up areas cover the land with solid surfaces such as roads, buildings, and pavements, and it controls intrusion and surface runoff. Secondly, unplanned urban development has created reclaimed wetlands, reducing the water retention and detention functions in flood plains. Thirdly, high sedimentation in the downstream drainage basins is caused due to soil erosion of upstream drainage basins as a result of deforestation (Abenayake et al., 2019).

Therefore, the urbanized areas need to provide proper plans by reducing the negative environmental impacts to achieve sustainability. Urban sustainability has become a new trend to address the adverse effects of human well-being and the natural environment. The concept of "urban sustainability" is described as the ideal state of urban condition with the rational use of natural resources, protection of the environment, reduction of the use of non-renewable natural resources, economic equity, and social well-being into urban development (Adinyira et al., 2007; Drakakis-Smith, 1997; Holden et al., 2008). There should be an equal concern on social, economic, environmental, and governance sustainability. These indicators are required to measure the performance of sustainable development as there is a need for measurable indicators in urban sustainability (Ugwu & Haupt, 2007).

2.2 Resilient Cities

Communities in resilient cities can resist, recover, and prepare for future revelations (economic, environmental, social, and institutional) to promote sustainable development, well-being, and equitable growth (Kounani & Skanavis, 2019). Urban resilience generally refers to the capacity to absorb, adjust, and adaptive the urban environment. Nevertheless, it is claimed that resilience shares many other main contemporary urban priorities, such as prosperity, stability, and economic growth (Tompkins & Hurlston-McKenzie, 2011). Additionally, resilience can be considered as one of the key concepts for operationalizing sustainability. Globally, all the cities have addressed challenges due to urbanization by providing clean air and essential services to the city dweller, safe and adequate housing, and thriving in resilient and sustainable communities to achieve urban sustainability (United Nations, n.d.). Cities must be resilient if they can be seen as competent to achieve urban sustainability (Getting Serious about Resilience in Planning, 2012). Resilient cities can cope with various challenges because they have flexibility, the capacity to reorganize and be integrated into the urban system (Melkunaite & Guay, 2016). This concept must become the focus of urban planning to form places that can manage and become the driving force for urban development (Kounani & Skanavis, 2019).

2.3 Disaster Resilience Actions Adopted by International Contexts

In 2013, Shaw et al. (2013) evaluated the disaster reduction approaches in Bangladesh, which is vulnerable to disasters in the last 150 years. Bangladesh has developed approaches for the risks of disasters such as floods, droughts, cyclones, etc. Rahman and Salehin (2013) have identified three innovative strategies to reduce the flood risk in Bangladesh. An evaluation of the measures taken against the risks caused by the cyclones in Bangladesh, it is noted that Bangladesh has multipurpose cyclone shelter, cyclone preparedness program, coastal afforestation, and coaster embankment to stand against the risks caused by cyclones as well as implement a cyclone resilient housing system (Mallick & Rahman, 2013). The study was conducted to assess disaster risk reduction in Nagpur, India, one of Central India's fastest-growing agglomerations with increasing urbanization (Dhyani et al., 2018). Urban environments are considered an essential contributor to emerging problems, threats, and potential solutions for many environmental challenges facing the city. In particular, the loss of agricultural and ' natural ' ecosystems would put more significant pressure on urban green spaces in rural areas in the city. An ecological strategy for Nagpur's smart growth would aim to restore the city's natural environment to a healthy state while renouncing direct facilities, tangible and intangible benefits from the green assets. Chou and Wu (2014) carried out a study about disaster resilience of urban communities in Taiwan, which implemented a disaster-centric approach in readiness for disaster situations. Oman was significantly affected by severe natural disasters annually. This situation was overcome by applying planning and emergency response to achieve greater disaster resilience (Al-Manji et al., 2021). However, the disaster management and resilience programs have never accomplished the same actions, policy prominence, or obtained financial contribution rates comparable to Asia or Latin America in the Southern African region. It is not just because of the disaster risk profile in South Africa, which has higher variations with disaster risk profiles of the other continents (Holloway, 2003).

2.4 Disaster Resilience Plans in Sri Lanka

Numerous hazards affect Sri Lanka, including events that are related to weather, such as cyclones, monsoon rain, and subsequent flooding and landslides (Disaster Management Center, n.d.). However, because of the diverse topography and environment in Sri Lanka, disasters vary immensely. Regional and regular floods pose the greatest threat to ecosystems and the flood risk profile owing to the increment in the intensity and frequency among hydro-meteorological hazards (Ministry of Disaster Management, 2014). Sri Lanka is following the Sendai framework introduced in 2015 for disaster risk reduction, especially for the hazards like flooding and landslides. According to this framework, identify disaster risks, then invest in disaster risk reduction to improve resilience and strengthen disaster risk governance to manage disaster risks (UNDRR, 2019). The National Emergency Operations Plan (NEOP) was established with the United Nations Development Program (UNDP). It defines the control process, the event command structure, the operating protocol, and the planning mechanism for a successful response to a disaster or emergency, the roles and responsibilities of the various stakeholders in a disastrous situation. The National Disaster Risk Management Policy (2013) has emphasized the rapid recovery of essential services and the enhancement of restoration and rehabilitation programs for the affected population in the medium and long term.

Additionally, institutional frameworks for early warning systems with country-wide coverage are created. The system consists of specialized organizations (such as the Department of Geological Survey, Meteorological Department, and Mines Bureau) responsible for monitoring threats of each form. In 2016 and 2017, the Ministry of National Policies and Economic Affairs and the Ministry of Disaster Management jointly implemented a Post-Disaster Needs Assessment (PDNA) for major catastrophic events such as Flood and Landslides, with funding from international partners including UNDP, the European Union (EU) and the World Bank. In 2018, Ahangama et al. (2019) stated that in Sri Lanka, there is a problem with the practical effectiveness of actions and approaches followed.

2.5 Effectiveness of Disaster Resilience Plans

The development plan is the key tool used to monitor and regulate physical development in urban areas. It introduces land-use control and infrastructure development as strategies to inspire socio-economic development and ecological management (Beltrão, 2013). With the increment in large-scale difficulties caused by climate change, overall development planning, especially spatial planning and building regulations, is insufficient to ensure sustainable development (Koubi, 2019). Saavedra and Budd (2009) emphasize the importance of understanding inherent local resilience and increasing this resilience through tactical intervention involving stakeholders. Pelling and High (2005) and Berkes (2007) mentioned that disaster resilience strategies are a fundamental part of developing a resilient process. In this stage, authorities need to identify a proper disaster plan with people's participation based on their needs, resources, and general safety, security, and quality of life (Maidin, 2008). However, there is no clear set of strategies to ensure public safety and protection against natural hazards, even though enhancing the quality of life is the general goal of most urban plans (Sandifer & Walker, 2018). Because of that, it is required at all stages of the planning process to achieve improved understanding and identification of critical issues and their resolution through socially acceptable, environmentally sustainable, technically viable, and economically feasible strategies to achieve an effective resilience development plan. Therefore, there were multidimensional approaches for measuring the effectiveness of the resilience plans. Table 1 provides factors extracted from the literature to achieve the research objective.

Table 1 Variable matrix

Main Factor	Sub-factors	Literature Source
Community Resilience	- Awareness program to improve public understanding of climate change & risk - Awareness program on hazard intensity & frequency - Practical training program for community - Inculcate saving & insurance habits among people	Adger (2000) Carpenter et al. (2001) Oddsdóttir et al. (2013) Berkes and Ross (2013)
Economic Resilience	- Recovery amount - Impact on income-earning opportunities - Secure and sufficient food supply - Access to financial services - Hazard resistant livelihood practices - Asset protection	Mancini et al. (2012)
Ecological Resilience	- Land use & management - The community adopted sustainable environmental management - Protect greenery & soil cover	Carpenter et al. (2001)
Emergency Readiness & Responsiveness	- Early warning system - Rescue actions - Post-disaster cleaning & other services - Relocation programme - Regulate the development of lands in flood areas - Solid waste collection /disposal & maintenance of drainage	Adger (2000) Berkes and Ross (2013) Oddsdóttir et al. (2013)
Infrastructure Resilience	- Electricity - Water - Health access - Transportation - Communication - Sanitary facilities	Berkes and Ross (2013)
Social & Cultural Resilience	- Community participation in plan-making - Women participation in plan-making - Community awareness of legal mechanism and other responsible actors	Adger (2000) Berkes and Ross (2013) Oddsdóttir et al. (2013)

3.0 CASE STUDY AREA

Ratnapura Municipal Council Area (RMC) is located in the Ratnapura Administrative District, Sabaragamuwa Province, Sri Lanka (Figure 1). It is situated in a valley surrounded by mountains. The Kalu Ganga, the country's second-largest river in terms of yearly runoff volume, passes through the city and is RMC's most prominent hydrological feature. The Kalu Ganga and its various branches discharge 7,600 million cubic meters of water into the ocean each year. The Way Ganga, Katugas Ella, Dodangaha Ella, Bambara Botuwa Ella, Denawaka Ganga, Mana Ella, and other minor streams all join to the Kalu Ganga in RMC. The Katugas Ella and Rajna Ella are two of RMC's waterfalls.

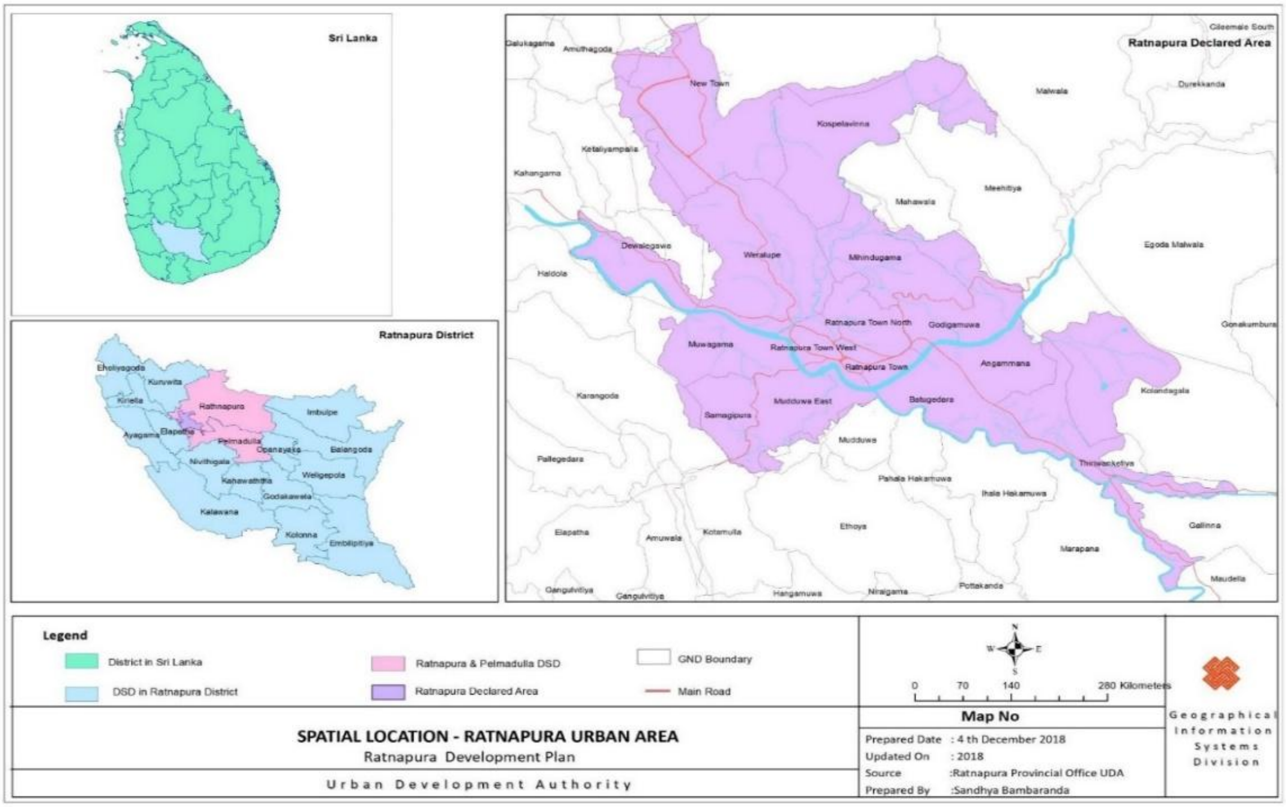

Figure 1 Location of Ratnapura

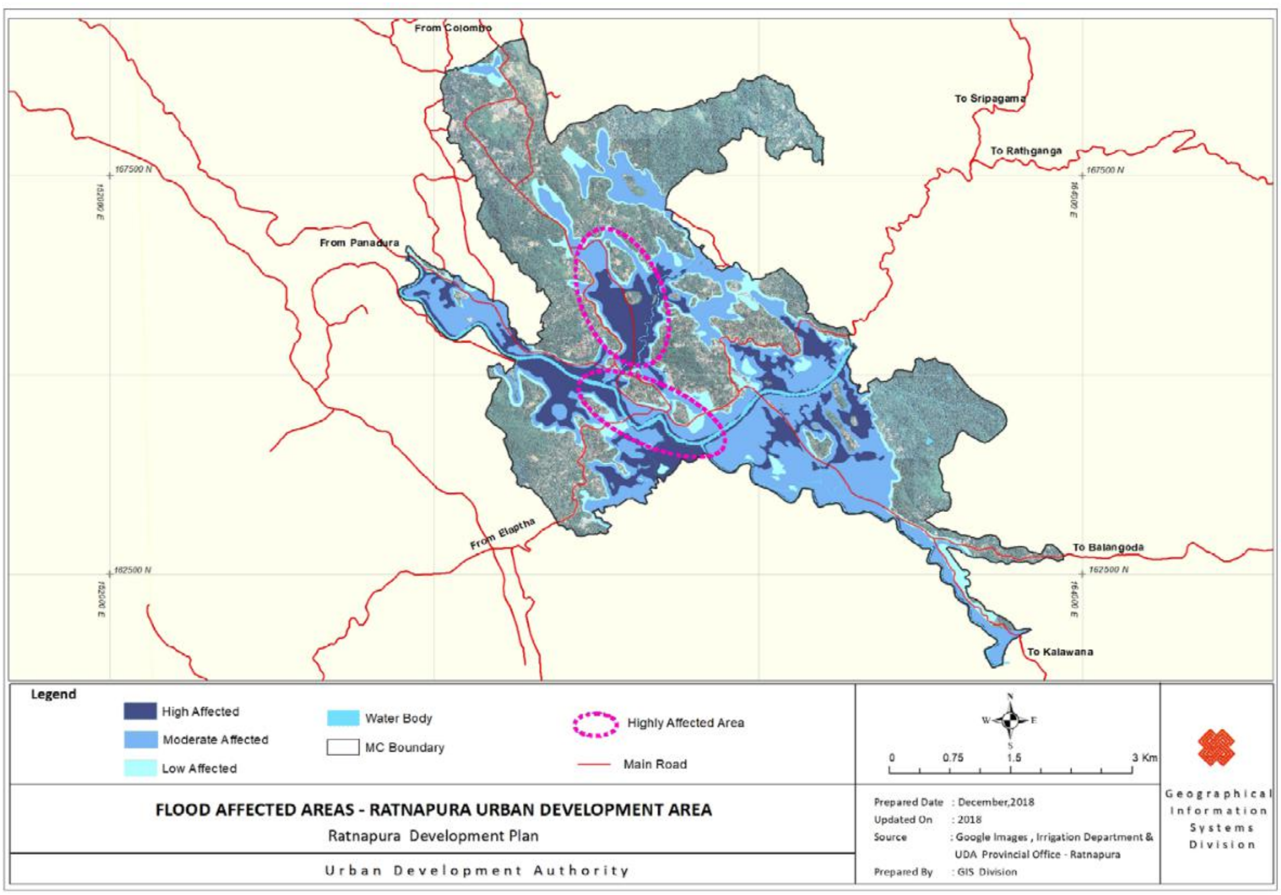

Figure 2 Flood affected area

Ratnapura is in the wet zone of Sri Lanka with average annual rainfall between 3000mm–4000mm. The highest rainfall is practiced during the southwest monsoon in May and June and during the inter-monsoon in September, October, and November. The lowest rainfall occurs in January and February. The average annual temperature is 29.4^{o}C in the area. The highest temperatures are generally recorded in March while the lowest is recorded in January. Therefore, Ratnapura MC Area is vulnerable to floods, and the irrigation department has identified the flood vulnerability in three ways: Minor Flood, Major Flood, and Critical Flood (Table 3). Ratnapura MC Area consists of 18 Grama Niladari divisions, and 11 divisions are vulnerable to flood effect. Major flood occurrences strike the town center once every ten years, causing catastrophic damage to life and property as well as disruptions to city functions (Hettiwaththa & Abeygunawardana, 2018).

Table 2 History of flood
(Source: Irrigation Department of Sri Lanka)

Type of flood	Return period	Level of flood	Recorded years
Critical Floods	50 years	Over 80ft MSL	1913,1947, 1989, 2003
Major Floods	10 years	70ft – 80ft MSL	1857,1872,1893,1924,1957,1969,1978,1982,1993,2017
Minor Floods	01 year	66ft – 70ft MSL	1939,1940, 1966,1967,2006

The most recent disastrous flood, categorized as a major flood, occurred in 2017. Out of the 18 Grama Niladari divisions in Ratnapura MC Area, only 11 divisions are vulnerable to floods. Those areas are, Muwagama, Angammana, Mudduwa, Mudduwa East, New Town, Ratnapura Town, Ratnapura North, Dewalegawa, Thiriwanaketiya, Weralupa, and Batugedara. According to the previous experience and records obtained from Divisional Secretariat Ratnapura, the frequency and past flood occurrences in each Grama Niladari Division were identified. The data proved that floods mainly occurred after April and continued till August, September, or October. The rainfall pattern appears to have directly impacted this situation, as 300 mm of rain is typically recorded in April, May, June, July, September, October, and November.

Table 3 Housing units and population affected by flood
(Source: Ratnapura Divisional Secretariat)

Grama Niladari Division	House units affect by flood		Affected population
	Minor Flood	Major Flood	
Muwagama	40-50	350-450	2,500
Angammana	80	350	1,400
New Town	05	15	71
Dewalegaawa	60	200	847
Mudduwa	-	121	484
Mudduwa East	50	360	1,440
Thiriwanakatiya	-	30	100
Batugedara	35	488	1,800
Weralupa	05	280	1,120
Ratnapura Town	12	129	412
Ratnapura North	-	45	183

According to Table 3, more than 40 housing units located in Muwagama, Angammana, Dewalegawa, and Mudduwa East are highly affected in a minor flood situation. Also, major flood situations highly affect housing units located in Batugedara, Muwagama, Angammana, and Mudduwa East.

4.0 METHODOLOGY

The study mainly focuses on residents' experiences in the flood-prone area, and 70 individual households located in a flood-prone area in RMC were selected through convenience sampling method to be given a structured questionnaire. Primary data were collected through this questionnaire survey, and it consists of 30 questions based on literature (Table 1). The dependent variable was assessed based on main factors. Sub-factors indicated in Table 1, and accordingly, six main variables considered for this study, namely Community Resilience, Economic Resilience, Ecological Resilience, Emergency Readiness and Responsiveness, Infrastructure Resilience, and Social and Cultural Resilience, given in the literature are considered as the independent variables of the study (refer Table 1).

The effectiveness of the flood resilience plan is the dependent variable in this study. It was indicated through the questionnaire using questions related to four factors: reduction in deaths and injuries after the flood resilience plan, reduction in flood occurrences through the current flood mitigation projects, level of implementation of the existing laws and regulations related to flood mitigation, level of knowledge of the authorized agencies and planners about the sensitivity to flooding risk (Table 4). In addition, secondary data were used to identify existing flood situations and plans. Those data were collected from Disaster Management Center, Irrigation Department Ratnapura, Urban Development Authority Ratnapura, and Divisional Secretariat Ratnapura. The data was statistically evaluated using correlation analysis, and the quantitative conclusions were qualitatively supported. As per the methodology, Figure 3 shows the conceptual framework of the study.

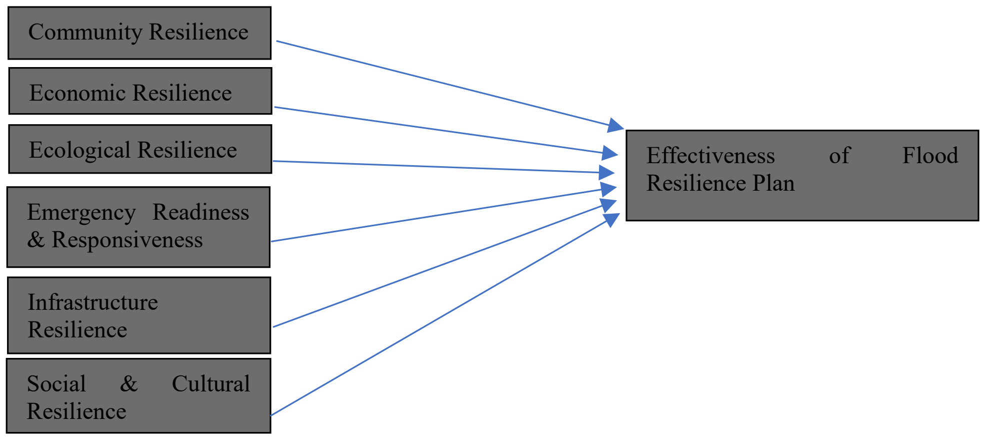

Figure 3 Conceptual framework for assessing the effectiveness of flood resilience plan

Table 4 Dependent and independent variables

Variable Name		Measurement	Factors
Dependent Variable			
Effectiveness of Flood Resilience Plan	EFRP	Continuous	- Reduction in deaths and injuries - Flood mitigation projects - Application of existing laws and regulations related to flood mitigation - Knowledge and sensitivity of flood situation about government agencies
Independent Variables			
Community Resilience	CR	Continuous	- Awareness programme - climate change & risk - Awareness programme on hazard intensity & frequency - Practical training programme for community
Economic Resilience	ER	Continuous	- Recovery amount - Impact on income-earning opportunities - Secure and sufficient food supply - Access to financial services - Hazard resistant livelihood practices
Ecological Resilience	ECR	Continuous	- Land use & management - Community adopted sustainable environmental management - Protect greenery & soil cover
Emergency Readiness & Responsiveness	ERR	Continuous	- Early warning system - Rescue actions - Post-disaster cleaning & other services - Relocation programme - Regulate the development of lands in flood areas - Solid waste collection /disposal & maintenance of drainage
Infrastructure Resilience	IR	Continuous	- Electricity - Water - Health access - Transportation - Communication - Sanitary facilities

Social & Cultural Resilience	SCR	Continuous	- Community participation in plan-making - Women participation in plan-making - Community awareness of legal mechanism and other responsible actors

The second objective of the study is to identify the relationship between the effectiveness of a flood resilience plan with the main factors. Accordingly, the following hypotheses were developed (see Table 5).

Table 5 Hypotheses of the study

No	Hypothesis
1	H0 = There is no significant relationship between community resilience and the effectiveness of a flood resilience plan. H1 = There is a significant relationship between community resilience and the effectiveness of a flood resilience plan.
2	H0 = There is no significant relationship between economic resilience and the effectiveness of a flood resilience plan. H2 = There is a significant relationship between economic resilience and the effectiveness of a flood resilience plan.
3	H0= There is no significant relationship between ecological resilience and the effectiveness of flood resilience plans. H3= There is a significant relationship between ecological resilience and the effectiveness of flood resilience plans.
4	H0 = There is no significant relationship between emergency readiness and responsiveness and the effectiveness of a flood resilience plan. H4 = There is a significant relationship between emergency readiness and responsiveness and the effectiveness of a flood resilience plan.
5	H0 = There is no significant relationship between infrastructure resilience and the effectiveness of flood resilience plans. H5 = There is no significant relationship between infrastructure resilience and the effectiveness of flood resilience plans.
6	H0= There is no significant relationship between social and cultural resilience and the effectiveness of a flood resilience plan. H6= There is no significant relationship between social and cultural resilience and the effectiveness of a flood resilience plan.

5.0 RESULTS AND DISCUSSION

The mean distribution of the variables shows the community perception about factors affecting the flood resilience plan (see Table 6).

Table 6 Mean values of factors affecting flood resilience plan

Variable	Mean	Rank
Emergency Readiness & Responsiveness	4.1714	1
Social & Cultural Resilience	2.6333	2
Economic Resilience	2.3595	3
Infrastructure Resilience	2.2905	4
Ecological Resilience	2.2667	5
Community Resilience	2.2357	6

Social & Cultural Resilience, Economic Resilience, Infrastructure Resilience, Ecological Resilience, and Community Resilience have mean values of 2.6333, 2.3595, 2.2905, 2.2667, and 2.2357, respectively. All variables have mean values which range from 2.23-2.64, except Emergency Readiness and Responsiveness. These results express that the community was more satisfied with Emergency Readiness and Responsiveness factor because it has recorded the highest mean value of 4.1714.

Cronbach's alpha was used to test the data's reliability, and the results are displayed in Table 7. As a result, Cronbach's alpha is equal to 0.864. When this score is more than 0.7, it suggests that the data has good internal consistency and reliability.

Table 7 Reliability statistics

Cronbach's Alpha	Number of Items
0.864	33

5.1 Testing Hypothesis

As portrayed above, Table 5 delineated the hypotheses created for the study. Subsequently, the following Table 8 depicts the results of correlation analysis.

Table 8 Correlations

Factors	Pearson Correlation	p-value
Infrastructure Resilience	0.805	0.000
Emergency Readiness & Responsiveness	0.708	0.000
Economic Resilience	0.630	0.000
Social & Cultural Resilience	0.552	0.000
Community Resilience	0.389	0.001
Ecological Resilience	0.252	0.055

As shown in Table 8, the p-values of the individual correlations between the effectiveness of flood resilience plan and infrastructure resilience, Emergency readiness & responsiveness, Economic resilience, Social & Cultural resilience, and Community resilience are all less than the significance level of 0.05, indicating that these correlation coefficients are significant. Infrastructure resilience has the highest positive correlation with the effectiveness of flood resilience plans. The other four factors also have a considerable positive correlation with the effectiveness of the flood resilience plan. However, the p-value of correlation between ecological resilience and effectiveness of flood resilience plan (0.055) is greater than the significance level of 0.05. Hence, the association between these two variables is not statistically significant.

Table 9 Results of hypothesis testing

Hypothesis		Sig.	Status
H1	There is a relationship between community resilience and the effectiveness of a flood resilience plan.	0.001	Accepted
H2	There is a relationship between economic resilience and the effectiveness of a flood resilience plan.	0.000	Accepted
H3	There is a relationship between ecological resilience and the effectiveness of a flood resilience plan.	0.055	Rejected
H4	There is a relationship between emergency readiness & responsiveness and the effectiveness of a flood resilience plan.	0.000	Accepted
H5	There is a relationship between infrastructure resilience and the effectiveness of flood resilience plans.	0.000	Accepted
H6	There is a relationship between social and cultural resilience and the effectiveness of a flood resilience plan.	0.000	Accepted

The outcomes of the hypotheses that were investigated are listed in Table 9. As a result, null hypotheses for five of the independent variables are rejected. Thus, the effectiveness of a flood resilience plan is significantly related to community resilience, economic resilience, emergency readiness and responsiveness, infrastructure resilience, and social and cultural resilience. These factors' correlation coefficients with flood resilience plan effectiveness indicate that they directly correlate with the dependent variable. As per the result, authorities must prioritize and pay close attention to these variables to develop an efficient flood resilience plan for Ratnapura. The null hypothesis relating to ecological resilience is accepted since its p-value is greater than α, indicating a statistically insignificant correlation between flood resilience plan effectiveness and ecological resilience.

5.2 Discussion

In addition to the above quantitative results, qualitative findings were evaluated to justify the study's quantitative findings. According to the qualitative study findings, a high level of accessibility and mobility facilities had been provided for the affected population to achieve infrastructure resilience during the previous hazardous situations. There is also an early warning system, an integrated hazard monitoring, forecasting, and prediction system. Website, community meetings, television/radio, and the megaphone are early warning tools used in the Ratnapura MC Area. The most prominent early warning method is the megaphone system in Ratnapura Municipal Council Area. Website and community meetings are ineffective because of the poor relationship between the communities and responsible authorities, such as the local authority and the Disaster Management Center in the area (Ahangama et al., 2019). This emergency readiness and responsiveness have been satisfactory, resulting in a beneficial influence on flood resilience in the area. Although a relocation program was implemented in the Kuruwita area of Ratnapura MC for flood victims in the New Town area, not all respondents had wanted to move because of the distance to the city centre.

Furthermore, the government has established a recovery method for residential properties to ensure Economic Resilience in a flood disaster. The assessor assesses the losses and determines the recovery amount. During the disaster period, they are usually granted non-government funds donated by non-governmental organisations (NGOs) such as United Nations Central Emergency Response Fund and UN-Habitat Funds. Therefore, implemented strategies for economic resilience have also positively impacted the flood-reliance plan's effectiveness.

The relevant authorities have carried out pilot initiatives for school children as well as capacity building and awareness activities for the local community, including experience sharing. The ecological resilience has been badly affected due to the improper execution of existing land use planning and building regulations, such as the illegal encroachment of river reservations and reclamation of the low-lying areas in Ratnapura. This may have adversely impacted the effectiveness of the flood resilience plan.

6.0 CONCLUSION AND RECOMMENDATION

Flood is one of the most prevalent natural catastrophes that can cause significant damage to people and the property. It is crucial to deploy adaptive measures and proper resilient techniques to prevent the massive negative repercussions of flooding. This will be beneficial to the city's urban sustainability as well. Therefore, the study aims to assess the factors affecting the effectiveness of flood resilience plans in the Ratnapura MC Area to achieve urban sustainability. The study's quantitative findings revealed that respondents' satisfaction with emergency readiness and responsiveness is higher than the other five independent variables. There is a positive relationship between five independent variables (Community Resilience, Economic Resilience, Emergency Readiness & Responsiveness Infrastructure Resilience, and Social and Cultural Resilience) and the effectiveness of the flood resilience plan. However, Ecological Resilience recorded an insignificant correlation with the effectiveness of the flood resilience plan. The quantitative findings of the study were also backed through qualitative results. The qualitative findings revealed that strategies implemented, such as providing accessibility and mobility facilities for flood-affected residents, installing an early warning system with modern technology, implementing relocation programs, providing recovery amounts, and conducting community awareness programs, all contributed to a resilient flood disaster management plan. Consequently, the infrastructure and social, economic, and emergency readiness actions have positively influenced the effectiveness of the Ratnapura Flood Resilience Plan to achieve urban sustainability. However, necessary efforts have not been taken to establish ecological resilience, and continuous improper management of land use and building regulations may negatively affect the effectiveness of the flood resilience plan.

The involvement of planning authorities is more important to strengthen the resilience of the Ratnapura MC area by focusing on the implementation of new ecological resilient strategies. The development of rainwater ponds with high water retention capacities and rooftop gardening can help achieve effective ecological resilience in the area. Further, integrated interventions related to infrastructure, community, economic, social, and cultural aspects also need to be improved to mitigate hazardous flood situations. It will be valuable to urban planners and decision-makers in implementing strategic action resilience projects and policies in future catastrophe mitigation planning to ensure urban sustainability by maximizing the city's resilient capacities. Finally, it can be used in the mass appraisal method and applied to real estate property development in Sri Lanka.

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