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Post-Flood Disaster Management Challenges and Issues in the Bulathsinghala Divisional Secretariat Division, Sri Lanka: A Comprehensive Analysis and Strategic Framework for Resilience and Recovery

Hansi Piyumi Nisansala Karadugoda Kankanamge [*1], Shakeel Mahmood [1]

[1]Government College University Lahore, Department of Geography, 54000, Lahore, Pakistan; (hansipiyuminisansala@gmail.com; shakeelmahmoodkhan@gmail.com)

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[*] **Corresponding Author**
hansipiyuminisansala@gmail.com

Abstract

Floods are frequently documented as severe catastrophic meteorological phenomena across the globe. In the context of Sri Lanka, floods constitute a significant natural calamity, predominantly occurring during the South-West and North-East monsoon seasons. A comprehensive investigation on the pre, during, and post-flood responses of the Bulathsinhala DSD area has not been conducted to date. The primary aim of this study is to identify the problems and obstacles pertaining to the management of urban flood hazards, and to propose an appropriate framework to enhance the existing flood hazard roadmap. The research methodology focused on the Bulathsinhala DS Division. Within this methodology, two GN divisions were selected using the judgment sampling technique from the thirteen GN divisions in the Bulathsinhala DSD area, for the sake of convenience in the study. Furthermore, the snowball sampling technique was employed to select 60% of the households affected by the 2019 flood in the aforementioned two GN divisions, for the purpose of primary data collection. The collected data, which was of the Likert scale type and aligned with the conceptual framework, was analyzed using the one sample t-test. This analysis revealed that more than 65% of the selected variables had a negative impact on the issues and challenges of urban flood hazard management. The findings of this research indicate that the evacuation and emergency response mechanisms in relation to the 2019 flood hazard were only effective in the short term. Various issues and challenges still persist in terms of finding long-term solutions. Multiple constraints related to existing regulations, institutional cooperation, resource availability, government involvement, and public attitude are evident, particularly during the preparedness, rehabilitation, and mitigation phases. Consequently, this paper recommends the implementation of far-sighted policies to overcome such issues and challenges.

1. Introduction

A Disaster is a calamitous event of slow or rapid onset that results in large – scale physical destruction of property, social infrastructure, and human life (Shaluf, 2007). It results in the existing resources and coping mechanisms of individuals, groups, communities and societies being overwhelmed. Floods are natural disasters and pose a threat to the lives, property, and infrastructure of the affected area. Even Hough the risk cannot be fully eliminated in a disaster-prone area, several methods can be used to manage floods, once they occur (Glago,2020). This includes identification of flood – prone areas, timely detection of the affected areas, mapping rescue routes and arranging logistics to carry out the rescue as soon as possible (Deeny & MCFetridge, 2005). The volume of water carried by a river is not the same every year due to complex meteorological factors and varying characteristics of the ground on which the rainfall occurs. The river is stated to be over flow when

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the flow exceeds the capacity within the river banks (Moges & Taye, 2019). The magnitude of the floods depends on the catchment characteristics, the intensity of the rainfall, its duration and the ground when the heavy spell of rainfall occurs (Breinl et al.,2021).

GIS (Geographic Information System) has emerged as a highly effective tool and technology in post-flood disaster management challenges. In the aftermath of a flood, the need for accurate and up-to-date information regarding the affected areas, infrastructure, and affected populations is critical for effective response and recovery efforts. GIS provides a comprehensive platform for data collection, analysis, visualization, and decision-making, enabling efficient coordination and resource allocation. According to a study by Kaviani et al. (2018), GIS-based flood risk assessment and mapping can help identify vulnerable areas, prioritize rescue and relief operations, and plan evacuation routes. GIS allows for the integration of various data sources, such as satellite imagery, digital elevation models, hydrological data, and infrastructure databases, providing a holistic view of the flood-affected region (Koks et al., 2019). Furthermore, GIS supports real-time data collection and monitoring, facilitating situational awareness and enabling authorities to make informed decisions during the post-flood phase. For example, Gao et al. (2019) highlight the use of GIS in monitoring water levels, flood extents, and road conditions, which can aid in assessing the impact on critical infrastructure and planning immediate recovery actions.

In addition to response efforts, GIS plays a vital role in long-term recovery and resilience-building. By analyzing flood patterns and vulnerability data, urban planners and policymakers can make informed decisions on land-use planning, infrastructure development, and flood mitigation strategies (Kuffer et al., 2016). The integration of GIS with other technologies like remote sensing and modeling tools further enhances the accuracy and reliability of flood risk assessments and disaster management strategies (Papathome-Köhle et al., 2016). GIS offers immense potential as a tool and technology for post-flood disaster management challenges. Its capabilities in data analysis, visualization, and decision-making enable efficient response efforts, effective resource allocation, and informed long-term recovery planning. By leveraging GIS, authorities can improve their understanding of flood dynamics, enhance coordination among response agencies, and promote resilience in flood-prone areas (Sebastiaan & Richard, 2012).

In Sri Lanka, floods are the most common type of disaster and flood risk is escalating due to deforestation, improper land use, and growing populations (Behzad et al., 2020). The most of floods are caused by overflowing rivers during the two monsoon seasons. The June 2019 floods were the worst disaster triggered by natural hazards in Sri Lanka. Kaluthara District, which is fed by the southwest monsoon rains, suffers from frequent floods. According to Carter, disaster management is a cyclical process for any hazard. [12] Basic steps should be considered in flood hazard management and those steps are: coordinated with the disaster management cycle; mitigation of flood hazard preparedness; response to flood hazard; and recovery from flood hazard. Although these steps are implemented by lot of countries to manage the urban flood hazard, there are many issues and challenges can be seen around the world especially in urban flood hazard management. Many of the contemporary researches have concentrated the issues and challenges of post flood hazard management (Bollin & Khanna, 2017).

Flood risk management needs to recognize the inter connections between infrastructures, economic systems and the role of human factors in assessing and managing the risk (Behzad et al., 2020). The challenge for flood management in the future is to develop robust and resilient solutions that perform well in uncertain future conditions. Post-disaster recovery involves the restoration and improvement, where appropriate, of disaster-affected communities' facilities, livelihoods, and living conditions, as well as efforts to reduce disaster risk factors. Grama (2020) the task of rehabilitation and reconstruction begins soon after the emergency phase has ended. It should be based on pre-existing strategies and policies that facilitate clear conventional responsibilities for recovery action and enable Community Participation. Grama (2020) referring to the Bulathsinhala flood area, most of the issues and challenges could be identified under this case as it was not well addressed to the requirements of the affected people. Therefore, this attempt is to determine the issues and challenges separately and introduce new strategies for the proper post-flood management mechanism. With this background, it is timely to address the issues of post-disaster management, including relocation and rehabilitation. Within the frame of the research problem, a few questions can be formulated as to the nature of post-disaster management in relation to floods in Bulathsinhala division. Therefore, finding the impacts of flooding in this area and finally, detecting the causes of issues and challenges in post flood disaster management.

2. Study Area

The Bulathsinhala Divisional Secretariat Division (DSD) area is in Sri Lanka's Kaluthara district. A total population of 71457 lives within the area. There are about 19 364 total families available, and among them, there are 15 098 total families affected by the disaster situation in 2017. It implies that 77% of families were affected by disaster situations in 2017 (Kumarasiri, 2018). Kalu Ganaga and Kuda Ganaga were identified as the two rivers in Bulathsinhala DSD. People who live on either side of the above rivers' river banks are frequently exposed to flood hazards. In particular, the lower part of the area and paddy cultivation are most vulnerable to flooding. Nevertheless, those areas are the most vulnerable to the flooding within Kaluthara district as well. The recent negative impacts have been more severe than in previous years. According to an investigation of the DMC records, there were 407 destroyed houses in Kaluthara District (UNDRR, 2019). Furthermore, according to Disaster Management Center statistics, Bulathsinhala DSD is one of the most affected DSDs in Kaluthara district due to the extreme flood situation.

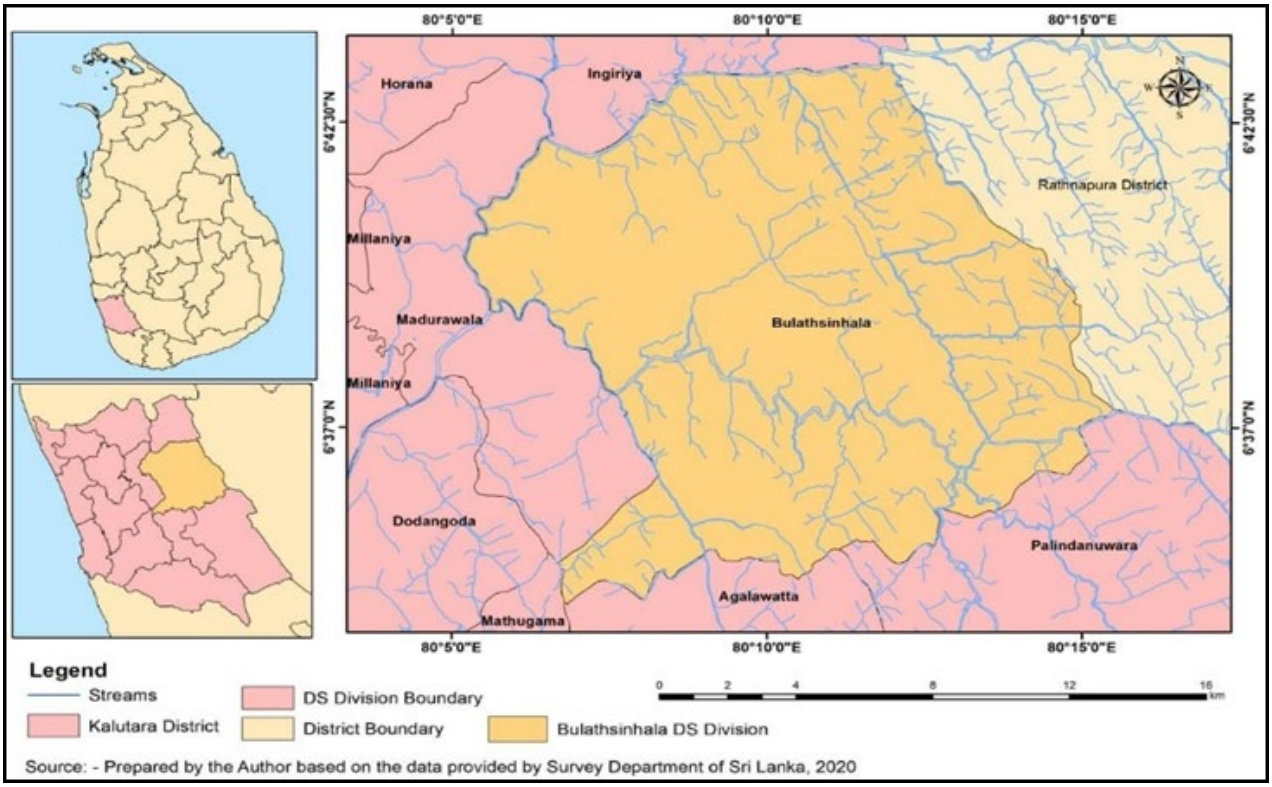

Figure 1. Study Area Map.

3. Methodology

The study used preliminary data from observations, interviews, and questionnaires and used data from 100 families affected by the floods in the Divisional Secretariat. The secondary data were collected from the Disaster Management Center (DMC) and the Department of Survey.

3.1. Conceptual Framework

The issues and challenges of post flood disaster management are the dependent variable (Y) of the study. In addition, as shown in figure 02, the various factors assumed to be affected in positive and negative ways by post flood hazard management were identified as independent variables (Xi-Xn).

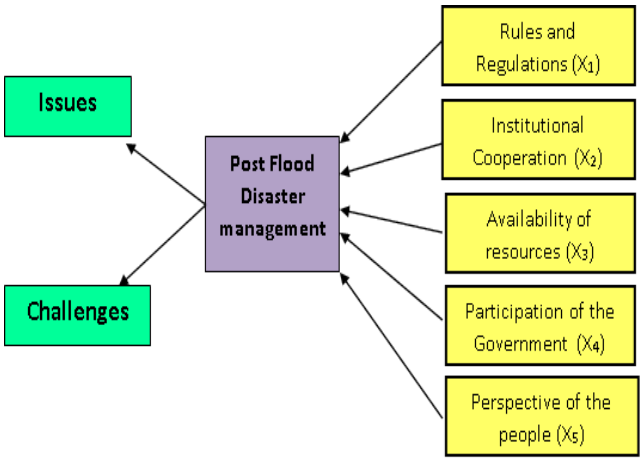

Figure 2. Dependent and Independent Variables.

According to figure 02, five variables were assumed in identifying the issues and challenges of post-flood hazard management. To begin with, rules and regulations that were causing issues and challenges in post-flood hazard management were identified as one of the variables. For post-flood hazard management in Sri Lanka, there is no exact policy (Rentschler et al.,2022). Due to outdated and updated rules and regulations relating to hazard management, some issues and challenges in the process of post-flood hazard management might arise. The impact of rules and regulations on issues and challenges was recognized by reviewing the applicability of suitable acts, rules, and regulations to the post-flood disaster management action in a practical framework.

Another possible variable, institutional involvement, could also be identified in this process. These variables were tested using data gathered from formal discussions with relevant institutions as well as the opinions of those influenced. The availability of resources and the participation of the government were also possible variables here. By discussing it with relevant authorities and the people, it was recognized. The attitude of the people is also one of the possible leading variables in the post-flood disaster guidance process.

The total population (100 samples) of this study represents the most flood-affected area in Bulathsinhala DSD, Kaluthara. For this research, five mostly flooded GN divisions were selected by using judgement sampling. Approximately 5% of the affected population due to the 2019 flood in selected GN divisions were selected by using the snowball sampling method, as shown in Table 01 given below.

Table 1. Purposely Selected GN Divisions, Number of Affected Families Due to 2019 Flood and Sample Sizes.

GN Divisions	Numberof Affected Families	Expected Percentage	Sample Size (Number of families)
Bulathsinhala western	250	5%	25
Diyakaduwa western	250	5%	25
Kudaligama	150	5%	15
Mahagama	200	5%	20
Galahena	150	5%	15
Total	1000	5%	100

Table 2. Data Collection Methods.

Type of Data	Type of Data	Source and method of Data Collecting	Data Analyzing	Data Presenting
Flood Data	Secondary Data	Disaster Management Centre – (2017) Books, journals, institutional reports, web sources	Descriptive Statistical Methods	Maps, Charts, Tables
Information of residential groups	Primary Data (100 Families)	Observations, Likert Questionnaire, Formal and informal discussions.	Descriptive and Inferential statistical Methods	Charts, Table, Maps

4. Data Collection Methods

Data was gathered by using primary and secondary data collection methods as follows:

According to this research, which is mainly based on qualitative methodology, when analysing data, basically descriptive statistical methods such as the measure of central tendency and the measure of dispersion were used. To quantify the qualitative data, a Likert scale is used to build indices as follows:

Highly disagree 1
Disagree 2
Neutral 0
Agree 3
Highly agree 4

Percentages of responses were calculated using the quantified data. After that, the data was descriptively analyzed for the impact of variables. Then, to test the impact of the independent variables on the dependent variable, a one-sample t-test was used. In order to confirm the quantitative analysis, the qualitative data collected through informal and formal discussions was analyzed descriptively.

5. Results and Discussion

Percentages There is evidence that this basin has been a habitat for humans for as long as 28 000 years. At present, the total population that occupies the river basin is about 1 million, and around 12% of this population lives in flood-prone areas. The population density of the study area is 312 per 1,000 km2. [17,18] This river basin attracts more people due to favorable weather conditions, water availability, fertile agricultural land, and the gem mining industry, making more people vulnerable to frequent floods. The Kalu-Ganga River passes through two administrative districts, Ratnapura and Kalutara, as shown in Figure 3. This paper focuses on analyzing floods in the upper reaches of the Kalu-Ganga River in the Ratnapura District. In Sri Lanka, administrative divisions within a district are named as Divisional Secretariat (DS) divisions, while as the lowest administrative division, a DS division is divided into several Grama Niladhari (GN) divisions [19].

5.1. Nature of Post Flood Disaster Management

Percentages People in this area had to face many problems after the 2017 flood, and many houses were damaged. Social impact has been identified based on the impact on family, social relationships, education, and health [20]. Deaths, as well as severely injured or disabled people, may be identified as having a social impact on families. When concerning the economic impact, their livelihood has been fully, partially, and less damaged, as shown by the Fig.4.

As a result, 21% of families have lost their entire livelihood, while 73% have suffered partial damage. It has been discovered that the economic impact was higher than the socio-cultural impact in the case of Bulathsinhala. Large numbers of families continue to suffer from wall cracks, dilapidated toilets, and broken toilets. About 20% of houses were at risk of wall cracks. Figure 05 shows some such damaged houses.

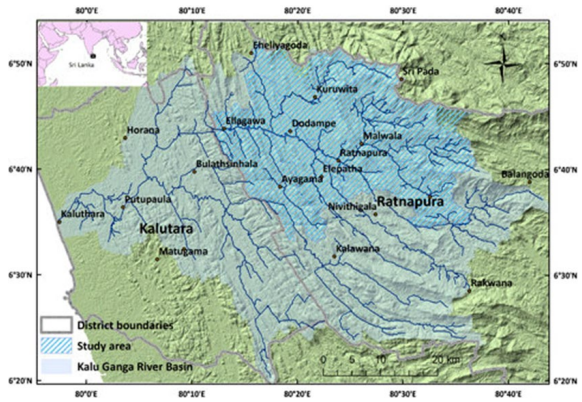

Figure 3. Flood Prone Areas of Bulathsinhala Division.

According to the field observations, the researcher identified 21% of houses as completely damaged. Also, the electrical wires and the system of houses were damaged and could not be repaired yet. 60% of the families were of the opinion that the compensation provided by the government for the construction of houses was not enough. Also, the majority of families in the Bulathsinhala Divisional Secretariat are tea growers, and hundreds of thousands of rupees have been lost due to the destruction of their tea plantations because of the flood. On the other hand, they have not been able to resume tea cultivation as they have not yet received any subsidies. Furthermore, some economic activities like agriculture, milk sales, tailoring, and farming were stopped due to the flooding. There were many problems with sanitation, and people were suffering from skin diseases and wounds. This study found 42 women in the Kudaligama area who had these diseases. Unfortunately, dengue patients have been discovered in the Mahagama and Kudaligama areas as a result of increased mosquito breeding sites following the floods. These economic and social issues were a source of stress for those who identified themselves as flood victims. Although the government intervened and provided assistance, irregularities have taken place.

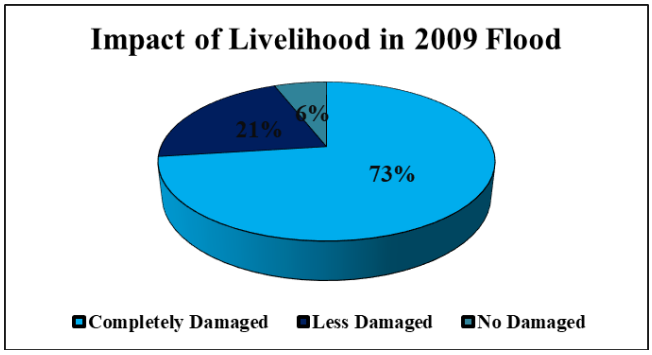

Figure 4. Impact of The People in This Area.

Figure 5. Wall Cracks in Damaged Houses.

5.2. Post-disaster Management Strengths and Weaknesses in Bulathsinhala DS Division

The strengths of the existing flood hazard mechanisms in Bulathsinhala seem to be somewhat different. Some of the key points are mentioned below. Weaknesses in the process of Post flood Disaster management in Bulathsinhala can be summarized as follows;

- Flood preparedness measures are not adequately maintained in the area.
- The post-flood disaster management system has not functioned positively in the related institutions.
- Lack of natural and manmade resources
- Poor planning and coordination by the authorities
- Poor distribution of human resources
- Lack of awareness and education for the people of this area
- Unplanned development and attitudes and culture of local citizens
- Officers are not enough for post-disaster management activities.
- Mitigation measures are not enough in the Bulathsinhala area.

The issues and challenges of post-Flood disaster management in Bulathsinhala Division were identified by researchers. In order to understand the issues and challenges of post-disaster management in the Bulathsinhala area, the significance as well as the impact of the following five variables were tested.Cooperation of the Institutions

- Rules and regulations
- Availability of resources
- Government Participation
- The attitude of the people

As stated in the methodology section of the study, a one-sample T-test is used to determine whether there is a statistically significant impact of selected variables on the issues and challenges of post-flood disaster management. Before performing the t-test, indices are built using Likert-type positive questions that were used in the questionnaire according to five variables. Additionally, before building the combined indexes, the reliability and validity of the collected Likert-type data were tested. Accordingly, the summary of the reliability and validity of the collected Likert-type data is shown in Table 3.

Table 3. Measurement Summary of The Reliability and Validity Tests of Accumulated Data, Source: Field Survey Data (2022).

Variable	Cronbach's Alpha	KMO and Bartlett's Test	P value
Positive Likert statements	0.929	0.699	0.00

According to the above table, in testing the reliability of the data, Cronbach's alpha value should be higher than 0.7; in testing the validity of the data, KMO and Bartlett's test value should be higher than 0.5; and the p value should be lower than 0.05 [21]. It is clear that all these conditions are fulfilled in the collected data set for the Bulathsinhala Area. So, the reliability and validity of the data set are ensured. The mean, median, and skewness of the built indexes are explained using the analyzed data to classify the issues and challenges of post-flood disaster management, and the 95% confidence interval of the difference is identified.

Table 4. Negative Impact of The T Test.

Variable	Test Value = 60, df =49, significant level= 0.05						
	N	Mean	St.de v	T value	P Value	95% Confidence Interval of the Difference	
						Lower	Upper
Negative impact	50	12.401	19.02	-16.898	0	-52.991	-42.312

Source: Field survey data (2020).

Table 5. Measurement Summery of Indexes.

Description	Sample (N)	Mean	Medi an	Skew ness	Min	Max
Negative impact of variables indexes	50	12 0.3 31	10.37 4	4.115	0 0	1 0 0

Source: Field survey data (2020)

Results show that the mean impact of the variables is 12.331 whereas the average impact is 10.374. Skewness is reported as 4.115, which confirms a positively skewed distribution of data. In a positively skewed distribution, the mean is greater than the median as the data is more towards the lower side, and the mean is the average of all the values, whereas the median is the middle value of the data. One-sample t-tests are widely used in many situations as a variable testing method in statistics. To fulfil the population distribution assumptions in order to test the variables in statistics, it is necessary. Therefore, a few expectations have to be fulfilled in this test. So, as a result, the data should be ordinal and have a normal distribution. The significance level of the means is tested in this test [22]. Accordingly, in order to test the negative impact of selected variables on issues and challenges of post-flood disaster management in Bulathsinhala Division, a t-test was performed with two hypotheses as shown below. The adverse effects of flooding include: loss of human life; property and infrastructure damage; road closures; erosion; and landslide risks.

H_0: The negative impact of selected variables on issues and challenges of post flood disaster management is equal or lower than 65%.

H_1: The negative impact of selected variables on issues and challenges of post flood hazard management is higher than 65%.

The negative effect of selected variables on issues and challenges in post-flood disaster management is 12.331 and the standard deviation is 19.01. Accordingly, the calculated DF value is -17.725. Compared to the 0.05 significant level, the calculated p value is lower than the significant level. So statistically, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. It means that there is a more than 60% negative effect of selected variables on the issues and challenges of post-flood disaster management. In this rapidly changing world, it is necessary to expand the definition of flood risk management to identify the important challenges faced by modern policy makers, practitioners, and scientists. Flood risk management must recognise the growing interdependence of physical infrastructure and economic systems, as well as the critical role of human factors in determining flood risk in the disaster management process. Innovative technologies are emerging to help manage flood risk, but these are not always straightforward to accomplish, and technology alone will not address all our challenges. As a result, the impact of selected variables on flood hazard management issues and challenges can be accepted.

The impact of selected variables on flood hazard management issues and challenges was demonstrated not only quantitatively but also qualitatively. By calculating the percentages of the negative responses for the positive Likert-type statements given by the respondents related to five variables, the negative response percentages for each statement of all variables were identified. Finally, as a result, among all the responses to the effective declaration related to selected variables, more than 50% of the negative responses were able to be recognized when considering each set of statements relating to each variable. So that can also be utilized as an indicator to identify the negative effect of selected variables on issues and challenges of post-flood disaster management in Bulathsinhala DS Division. According to the affected area communities' opinions, the subsidies were not given to the flood victims but to the people who were not affected. Respondents felt that this problem appeared because of the poor performance of their Grama Niladharies. Otherwise, because of their bias toward certain groups in this area, the study finally identified some issues and challenges in post-flood disaster management in this area.

Even though there was good institutional contribution in different places in the Bulathsinhala area during the hazard, in the rest of the phases of the hazard management process, inadequate contribution and cooperation were identified. Uneven donation

distribution, the inability of schoolchildren to attend classes, socioeconomic issues, and delays in repairing damaged roads and other infrastructure facilities and then researchers found some causes for those related issues. These are the lack of strong institutional arrangements; a lack of responsibility provision; failures in providing educational facilities at the initial stages; a lack of socio-cultural studies of community attitudes; and a lack of authority's support (Field Survey, 2020).

Under the variable of rules and regulations, the inadequacy and lack of flexibility of the existing rules and regulations, which mainly impact the forced evacuation process while the hazards are present, regulations related to mitigation mechanisms such as the permanent removal of illegal settlements in flood-prone areas, and also the clash of the rules and regulations with the authority of different institutions in the disaster management process, were mainly identified.

Although the three forces of Sri Lanka were involved in the hazard management phases in Bulathsinhala DS Division, the lack of material and human resources, mainly in the evacuation phase and also in the rehabilitation phase, was identified in terms of the evacuation of people by boats and helicopters, providing temporary shelters and basic needs, and also providing long-term solutions for resettlement. The government's involvement was visible throughout all phases, but the inadequacy of the involvement and creeping actions of providing long-term solutions such as compensation and resettlement were identified. The most important process of hazard management is managing the vulnerability and exposure of the population and built environment. Under the variable of the people's attitude, the less awareness of the people in the Bulathsinhla Area, as well as the less preference of the people for the hazard management phase, the less awareness of the people about existing rules, and the low level of attitude of less educated people about the standard procedures in providing temporary and long-term solutions in each stage of flood hazard management, were identified.

6. Conclusion and recommendations

Finally, the study identified some weaknesses in the post-flood disaster management process in this divisional secretariat division. However, there were some strengths, such as the well-established operational cabin during the hazard, the integration of relevant institutions, the proper evacuation mechanism, and the cooperation of people while providing basic needs for the affected people with the unity and satisfaction level of the property damage estimation mechanism, etc. Additionally, they emphasized that preparedness and post-disaster management planning in this area were slow. So, most of the issues and challenges were recognized under the phases of long-term reconstruction, rebuilding, and community development. The impact of selected variables was proved by calculating the negative response percentages, and the negative impact of all variables was proved by using one sample t-test. Rather than the issues and challenges related to the selected independent variables, the issues and challenges were also identified in the process of post-disaster management in Bulathsinhala DSD.

The lack of strong institutional arrangements has caused this situation to arise. and also identified that the officers are not enough at different stages of the post-flood disaster management process. Lack of adequate temporary relocation places for evacuated people; difficulty of providing facilities in temporary relocation places according to racial differentiation; nonfulfillment of the vacancies of the officers; unethical activities of certain gangs of people; and high political interference and bureaucracy. In addition, it can be concluded that people's attitudes also have considerable influence in increasing the complexity of the issues and challenges of post-flood disaster management. Furthermore, establish a proper mechanism to enhance institutional coordination and commitment. Responses also mentioned that boats be provided to travel to a safe place during floods and that accommodations be provided. So, affected communities should have access to assistance for the speedy recovery of disrupted livelihoods. Cultivation provides them with a better opportunity to rebuild their lost assets and contribute to housing repair and reconstruction. Therefore, the administrative structure at the state level should be developed, and the authorized officers should be used appropriately for these post-flood management projects. Relief centers should be established, and they should be designated an action committee for the emergency. It is also important to conduct public awareness programmes and develop the attitudes of the people in Bulathsinhala.

6.1. Following Suggestions Can Be Proposed According to The Selected Variables;

- Rules and regulations
- Flexibility and the power of the existing rules and regulations should be enhanced and the outdated (Mitigation rules related to the evacuation of people from illegal and vulnerable areas should be formalized.)
- Institutional involvement
- Institutional cooperation should be improved at each stage of hazard management by closing the gap between cooperating while hazardous conditions exist.
- Determine the Availability of resources
  Both physical and human resources should be equally focused on the requirements.
  Involvement of the government Even though the local authorities are responsible for many regional activities, those activities related to hazard management should be under the supervision of the central government.
  Involvement of the government in each stage of hazard management should be ensured.

6.2. People's Attitudes

The individuals who have been affected by flood events have experienced a range of emotions including anxiety, fear, anger, frustration, sorrow, and mourning. It is typical for individuals who have encountered traumatic

incidents like floods to face difficulties such as insomnia, decreased appetite, sentiments of depression or anger, and heightened anxiety. The creation of a public relations bureau that is organized by divisions could enhance the understanding and handling of these perilous circumstances and the endeavors connected to them.

Author contributions

Author contributions are equal in this study.

Conflicts of interest

The authors declare no conflicts of interest.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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