

## **ABSTRACT**

Throughout human history, hazards have been a recurring occurrence, and it is widely recognized that we cannot completely eliminate their existence. This is especially true for natural hazards, as they are beyond our control. However, while we may not be able to prevent these events from happening, we can take measures to mitigate their impact and prevent them from escalating into catastrophic disasters through efficient planning and preparedness. Among the multitude of disasters, flash floods stand out as particularly devastating on a global scale. These events have the potential to escalate rapidly and inflict widespread damage in a very short span of time. Flash floods have posed a significant threat to Alipurduar District, earning it the reputation of being a flash flood-prone area. This study provides an overview of the factors contributing to flash floods in the District, their impact on the local ecosystem and socio-economy, and potential measures to mitigate the damage caused by these natural disasters. The region's diverse topography directly influences the severity of flash floods, with the hilly areas and foothills in the north of Alipurduar District being particularly susceptible. The rivers originating from the Bhutan Himalayas play a crucial role in triggering sudden slope changes and heavy rainfall, carrying substantial amounts of water, sand, and stones through the District. When these rivers reach the foothill areas, they deposit excess materials, elevating the riverbeds and causing sporadic flash floods during the monsoon season. Human activities such as mining, quarrying, and deforestation further exacerbate the impact of flash floods, disrupting the natural balance and increasing the District's vulnerability. Over the past few decades, numerous flash flood incidents have occurred, predominantly affecting the foothill areas in the north of the District. This research aims to shed light on the causes of flash floods in Alipurduar District and explore potential mitigation methods. The study delves into the relationship between flash floods and heavy rainfall, drainage systems, topography, human influence, and the elevation of riverbeds. Additionally, the research highlights the extensive impact of flash floods on human and livestock casualties, river course alterations, water quality, ecosystems, cultivation, forests, tea gardens, and the socio-economic condition of the District. The thesis is divided into eight chapters.

The introductory chapter (Chapter I) provides an overview of flash floods, the study area, research objectives, the database and methodology employed, statement of the problem, and the significance of the study. Chapter II offers a brief description of the physical and cultural characteristics of Alipurduar District, covering topography, geology, climate, natural vegetation, drainage systems, population resources, and tea gardens.

Chapter III discusses the drainage system of Alipurduar District in detail. This chapter provides detailed information about several small rivers in the study area. Source, course details, total catchment area and total length of each river are determined. Basically, the detailed information about the rivers has been presented with the help of long term field observation experience and Google earth. In this chapter river bank erosion sites are identified through field observation and discussed through photographs. The morphological characteristics of the rivers in the study area are discussed in details. Morphological features like alluvial fan, braided channel, meander, ox-bow-lake, point bar, sand bar, river island etc. are identified and discussed. Finally, in this chapter, the channel transformation of various rivers is discussed in details.

Chapter IV extensively explores the causes of flash floods in Alipurduar District, with a particular emphasis on rainfall data. Rainfall data for the last 30-35 years has been reviewed in detail by collecting data from CWC, Irrigation and Waterways Department, Tea Gardens and Govt. agricultural farms. Each flash flood that has occurred in the study area, is discussed with evidence by collecting newspaper cuttings. The causes and damages of flash floods of 1993, 1998, 2000, 2004, 2007, 2010, 2014 and 2017 are highlighted. A separate household survey was conducted to discuss the causes of the 1993 flash flood. Data regarding the date and years of flash flood was collected from the clock offices and the cause of flash flood was discussed. The relationship of rivers with slope is discussed to determine the extent to which topography is responsible for flash floods in Alipurduar District. Field observations and photographs were collected as evidence to determine the extent to which river projects and construction barriers were responsible for flash floods. The details of the quarrying of various rivers in the study area have been discussed. The impact of upper catchment area dolomite mining on flash floods is discussed. During the field observations various photographs were collected to know the impact of mining and quarrying activities on flash floods.

Chapter V examines the nature of flash floods in Alipurduar District, including flash flood frequency, flash flood magnitude index, duration of flash floods, and a historical overview of flash flood events. The discussion of this chapter is mainly based on CWC's discharge data, water level data and rainfall data. Recurrence Intervals of three major rivers (Torsa, Raidak-I, Raidak- II) of Alipurduar District are discussed to obtain information about the frequency of flash floods. Generally, the effect of flash flood is seen in the whole District mainly after 2-3 years. However, flash flood occurs every year in Ballalguri, Totopara, Jamtala, Bandapani, Jayanti, Mechpara, Radhrani, Chuapara, Hatipota etc. In the northern foothill areas of

Alipurduar District, flash flood water mainly stays for 2-3 hours, but in the southern plains it stays for 12-36 hours. On the basis of flash flood susceptibility, Alipurduar District has been divided into four parts and discussed about them in details. Flash Flood Magnitude Index (FFMI) of Torsa, Raidak-I and Raidak-II Rivers have been determined through discharge data. From the information of the District Disaster Management Plan, it has been seen that in this District, Madarihat-Birpara, Kalchini and Kumargram block are the most flash flood prone. Data of Qmax and water level of 1993, 1998, 2000, 2007, 2010 and 2017 were reviewed to know the nature of flash flood in details.

Chapter VI, considered the core of the research, focuses on the effects of flash floods in the District. In this chapter, a household survey was conducted on 860 households to know the various effects of flash flood in Alipurduar District. Based on that, it has been possible to bring out various information. Data on human life lost in 1993 was collected through CWC integrated data book, newspaper cuttings as well as household survey. The mainstay of Alipurduar District's economy is the tea industry. Naturally, the effect of flash flood is more on the tea gardens. The effect of flash flood of last 30-35 years on tea plantations has been discussed through the data obtained from Dooars Branch Indian Tea Association (DBITA). Tea gardens affected by flash flood have been identified through field observations and maps have been made with the help of Google earth and ArcGIS software. Information about the effect of flash flood on forest has been collected and discussed through field survey. Photographs of tea gardens and forests affected by flash flood in different years were collected during direct field observation. Some secondary data regarding flash flood affected forests were collected from different secondary sources. The impact of flash floods on crop pattern change in the northern part of the study area is discussed in detail. Information on flash flood affected construction and property loss across the District has been presented. Photographs of flash flood affected constructions and properties have been collected through field observations. This chapter discussed the effect of flash floods on soil properties. The water of various rivers of Alipurduar District is being affected for dolomite mining and in-stream quarrying. Water samples have been collected and tested from different rivers to provide detailed information on this matter. The Water Quality Index (WQI) table is created based on the weighted Arithmetic Water Quality Index (WAWQI) method. To collect data on river bed rising in the study area, river bed elevation has been measured regularly in different rivers during Pre-monsoon and Post-Monsoon periods for the last 6-7 years. Data and photographs of river bank failure in different parts of the District due to the effect of flash flood have been collected and discussed. Field

observation was done and photographs were collected to know about the river valley enlargement. River channel transformation due to flash floods is also discussed. Finally, this chapter briefly discusses the positive effects of flash floods.

Chapter VII outlines proposed remedial measures for flash floods in the study area, identifying vulnerable zones and rivers, and suggesting strategies and measures to mitigate the effects of flash floods. In this chapter, the guidelines given by WHO regarding flash floods have been discussed in detail. During the field observation, it was observed that the presence of forest in the foothill regions of the northern part of Alipurduar District has been able to resist the intensity of flash floods to a great extent. Hence the importance of forest in flash flood prevention is discussed in detail with photographs. Uses of local available materials (Sand, boulder, bamboo, bad materials, etc.) also discussed with photographic evidences. Finally, Chapter VIII presents the major findings of the research and offers a comprehensive conclusion. Finally, this research contributes to understanding the causes and impacts of flash floods in Alipurduar District. It provides insights into the vulnerabilities of the region and proposes potential solutions to minimize the devastating effects of flash floods. By addressing the various aspects discussed in this study, stakeholders can work towards building a more resilient Alipurduar District in the face of flash flood events.