A Study and Simulation of Cloudburst event Over Uttarkashi Region using River Tool and Geomatic Techniques

V.V.Govind Kumar, Kamal Jain, Ajay Gairola

Abstract*—In Uttarakhand state, India subjected to frequent occurrence of natural disasters like Cloudburst. Flooding due to Cloudburst is the extreme form of Natural disaster. This leads flash floods/ landslides, house collapse, dislocation of traffic and human casualties on large scale (Sati and Maikhuri, 1992) The average rainfall for Uttarkashi district varies 1500-3000 mm a year. The purpose of this study is to Analyses the Natural Disaster events like CloudBurst using RiverTool and Geographic Information System. In the first stage, locations of Cloudburst were identified from field survey and Indian Atlas. In the second stage, the layers Slope, Drainage pattern and LandUse classification are generated from AsterDEM and Landsat ETM+ data. The influence of Drainage characteristics, slope angle and LandUse Classification were spatially integrated to analyse one of the Natural Disaster like Cloudburst in the Uttarkashi District, Uttarkhand State, Northern part of India where a large number of Cloudburst happened due to extreme weather event of Aug 3–6, 2012. The villages Ravada, Paniyara kala, Andhyara kala, Sangamchetty are totally effected and 34 persons died, 7 Bridges of vehicle and 6 Bridges of footpath were washed away resulting in no connectivity with Bhatwari area, 1700 families are affected from Gangori to Uttarkashi, Around a population of 80000 is affected from this disaster.

A quantitative technique of multivariate analysis was performed to analyse theware conducted for different excess rainfalls. A natural disaster is the consequence of the combination of a natural hazard (a physical event e.g. volcanic eruption, earthquake, landslide, flooding, etc.) and human activities. Therefore, for better understanding of this event, Mapping and analysis of hydrological Parameters are carried out in Uttarkashi region. Uttarkashi and its surrounding regions of the trans-Himalaya experienced multiple cloudbursts and associated flash floods during August 3–6, 2012.

***Keywords*— Cloudburst, Geographic Information System, Flash floods, Landsat ETM+ and Aster DEM.**

I. INTRODUCTION

Cloudburst is one of the major Natural Disaster in Uttarkhand and Himachal Pradesh States in India. Deep cumulus convective clouds have a capability of giving enormous amount of rainfall over a limited horizontal area, within a short span of time.

Such types of extreme rainfall events are most common over the high elevated areas of Northern India during the Southwest monsoon season which causes widespread damage to the property and lives.

Such events, whenever they occur, lead to flash floods, landslides, house collapses, dislocation of traffic, and human casualties on a large scale (e.g. Bombay cloudburst, 25th july2005 and Leh, 2010). A 'Cloud-Burst' is a localized weather phenomena representing highly concentrated rainfall over a small area (not exceeding 20–30 km2) lasting for few hours (sravan kumar et.al,2012). Cumulus convective clouds are developed deeply on a localized area which has a capability of giving enormous amount of rainfall over a limited horizontal area, within a short span of time. It represents cumulonimbus convection in conditions of marked moist thermodynamic instability and deep, rapid dynamic lifting by steep orography (Das *et al*. 2006). Meteorologists say the rain from a cloudburst is usually of the shower type with a fall rate equal to or greater than 100mm (4.94 inches) per hour. During a cloudburst, more than 2cm of rain may fall in a few minutes (Govind *et. al*, 2012). A heavy downpour occurred over the terrain slopes, and due to week soil and friction, the rain water along with the rocks and mud gushed through the populated areas. As the event took place around midnight, many people lost their lives and their properties.

In India, cloudbursts occur during the monsoon season due to strong convection associated with orographic forcing over the Himalayas, Western Ghats and northeastern hill states. This convection in the form of cumulonimbus cloud can rise up to 15 km with marked instability and deep convection with orographic forcing. Hence, thermodynamic and orographic forcing act together in the formati Studies have also shown a relationship between the Himalayan topography and the Indian summer monsoon (ISM) (Bhaskaran et al. 1996; Barros et al. 2000; Kriplani et al. 2003, Barros and Lang 2003; Bookhagen et al. 2005; Barros et al. 2006; Anders et al. 2006; Bookhagen and Burbank 2006).on of extreme cloudburst event (Das et al. 2006). However, our field investigations revealed that the Cloudburst occurred on a mountain top close to Dayara Bugyal and storm was much more extensive with flash floods in the streams Assiganga and Ganga River on midnight of 3rd August 2012.

II. METRIALS AND METHODS

Study area: Cloudburst and associated flash floods are one of the most potent disasters occurring in the Himalayan region.

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Due to spate of cloudburst events in Uttarkashi District and its surrounding regions experienced devastating flash floods during August 3–5, 2012. Uttarakhand is the state in the northern part of India. It is often referred to as the "Land of the gods" due to the many holy Hindu temples and pilgrimage centers found throughout the state. The study area Assiganga lies in the Upper Ganga Basin, Uttarkashi District and is bounded by the latitudes 30°43' 47.00" N-30°55' 51.05" N., and the longitudes 79°4' 46.13" E-79°16' 9.45" E. The topographical representation of Study Area is shown in Fig 1. Most of the northern part of the state is covered by high Himalayan peaks and glaciers. The Altitude of the study area ranges from 1600 to 3300 meters above sea level (ASTER DEM). A lowest winter temperature of 7 ^{0}C and a highest summer temperature of 36^0 C have been recorded at Uttarkashi in 2012, and it has a mean annual precipitation of 1500-3000 mm. The Assiganga River is one of the tributary for Ganga River. The total area of the watershed is 176.89sq.km. For every year thousands of pilgrims are going to Gangotri, Badrinath and Kedarnath etc (Govind et.al,2012). There are number of streams flowing through this arid land which are mostly fed by snow and glaciers. Uttarkashi is a junction point for all the historical places in northern Himalayas. Due to Cloudburst the Roads are totally damaged and most of us are faced lot of problems when cloudburst occurred in night of 3rd August 2012 in Assiganga area. Field Data Collection with Handheld GPS after post processing over laid on the Landsat ETM+ shown in Fig.2.

Datasets: ASTER GDEM used for the delineation of the catchment area and drainage pattern. The ASTER GDEM covers land surfaces between 83°N and 83°S and is composed of 22,600 1°-by-1° tiles. The ASTER GDEM is in GeoTIFF format with geographic lat/long coordinates and a 1 arc-second (30 m) grid of elevation postings. The multi-spectral satellite data of Landsat ETM+ and High Resolution satellite data (Google earth) for the year 2005 have been procured in the present study (see table 1). The Landsat data used in current investigation system was downloaded free from the USGS Global Visualization Viewer (GLOVIS). The Cloudburst hit Uttarakhand state in 2012 according to Disaster mitigation management center (DMMC), Dehradun are showed in Table 1.

Land use Land use is the factor related to the effects caused by human activities on landslide occurrence. The study area is covered mainly by dense and sparse forests (Gemitzi A et.al, 2010). To a lower extent grasslands and residential areas (mainly in the form of small settlements) occupy the study area. Moreover, zones of 50 m around main road to sangamchetty and Assiganga Rivers were delineated and incorporated in the land use layer, which correspond to the adjacent to those features pixels, which are the ones that might have been influenced by the presence of rivers or the construction of roads. The status of vegetation and land use coverage in the

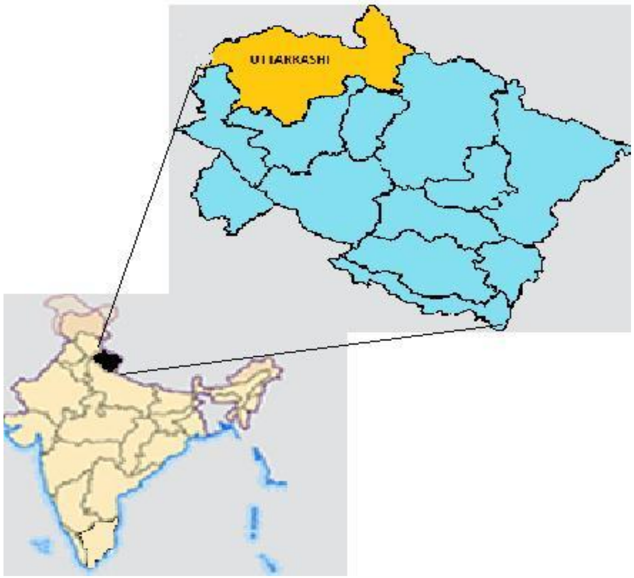

Fig.1. Topographical representation of the Study area.

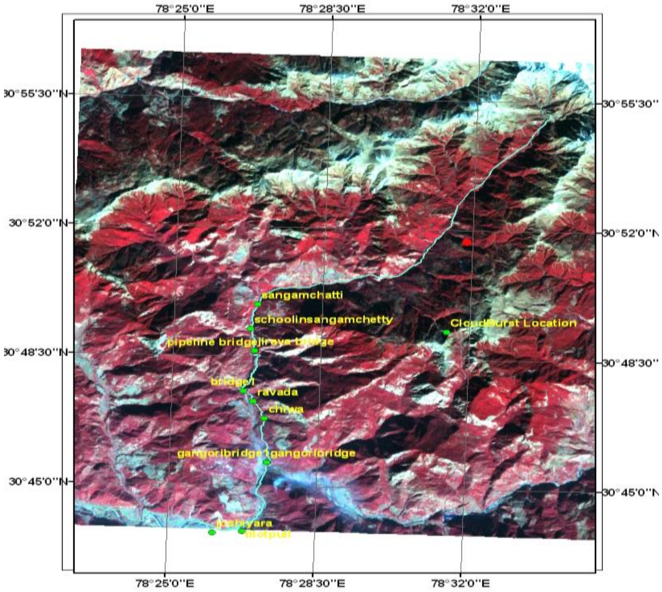

Fig.2. GPS data overlaid on Landsat ETM+ showing Cloudburst Location

Table-1 Details of Cloudburst in Uttarkhand, 2012

Date	State	District	Effected Villages
05/07/12	Uttarkhand	Uttarkashi	Assi ganga ghat, Charaghani, Andiyarakala, Phaniyarakala, Ravada
05/07/12	Uttarkhand	Chamoli district	Beriya area
04/08/12	Uttarkhand	Uttarkasi	Dayara bhugyal , Joshiyada, Gangori bridge
19/08/12	Uttarkhand	Uttarkasi	Nuranu village, Mori area
14/09/12	Uttarkhand	Rudraprayag	Timada, Sansari, Giriya, Chunniand, Mangali ,Premnagar and Juatok villages in Ukhimath area
14/09/12	Uttarkhand	Bageshwar district	Kapkot near Almorah

Uttarkashi region are varies depend on the topographic feature of such places. The areas within the rugged hilly zones in the northern and central part of the region are still Rain forest, except on several places those having good water catchments, Bridges and Culverts have been built along the Assiganga River for Transport consumption to entire population of the region.

Slope

The most important parameter in the slope stability analysis is the slope angle (Lee and Min 2001). Because the slope angle is directly related to the landslides and it is frequently used in preparing landslide susceptibility maps (Clerici et al. 2002; Saha et al. 2005; Cevik and Topal 2003; Ercanoglu and Gokceoglu 2004; Lee et al. 2004a; Lee 2005; Yalcin 2005). For this reason, the slope map of the study area is prepared from the AsterDEM.

Drainage pattern

An important parameter that controls the stability of a slope is the saturation degree of the material on the slope. The closeness of the slope to drainage pattern is another important factor in terms of stability. Streams may adversely affect stability by eroding the slopes or by saturating the lower part of material until resulting in water level increases (Gokceoglu and Aksoy 1996). It has been assumed that the intermittent flow regine of the streams and gullies in the basin encompasses remarkable erosive process, which, in turn, is the cause of intense, superficial mass wasting phenomena in areas adjacent to drainage channels.

III. RESULTS AND DISCUSSIONS

In Analysis, the Landuse classification of the study area is done using ERDAS Imagine 2010. Database collected from the Upper Ganga Basin Plan the study area is classified into five categories which area Forest-Evergreen, Pasture, Forest-Mixed, Water, Range Grass, Fallow land and snow. The prepared LandUse Classification map is shown in Fig.3 and results are presented in table .2 It can be seen from the Analysis that 88 percent of the area is either covered by forests or is barren and uncultivable. The hilly areas within the hilly zones up to 2800 meters height are mostly cultivated with paddy, small millets, potato, wheat and other fruit trees.

Table-2.Types of the LandUse Classifiactions

S.No	Classification	Area (km^2)
1	Forest Evergreen	73.49
2	Pasture	61.54
3	Forest-Mixed	25.54
4	Water and Range Grass	11.90
5	Snow and Fallow land	4.39
Total		176.89

These crops account for over 80 percent of the total cropped area. The multi-racial populations mostly concentrate on the low-flat areas of the region. The Major population density are in the downstream of the Ganga River. The areas within the rugged terrain zones in the north-western indicate sparsely populated due to the topographic condition.

The slope map of the study area is prepared from the DEM, and divided into 5 slope categories which are shown in the Fig.4 The Delineation of the watershed done by using River Tool software and ArcGIS. The Basin Characteristics of the study area are shown in Fig 5. the Drainage pattern analysis done in Rivertool shown in Fig.6 and Drainage Characteristics of Assiaganga represented in Table 3and Table 4. From the analysis in ArcSWAT Tool in GIS the soils deposits occur in the region are Swanton, Scanty and Vergennes. As per stray surveys, soap stones, iron, graphite, limes stone, kyanite and mica.

In Assiganga Area the cloudburst happened in 3300m approximately. The elevation Profile of the area varies from 3050m to 1600m. The Channel Profile of Assiganga from Top of Sangamchetty to Gangori is around 60 km and elevation profile with contours of the Assiganga is showed in Figure 7. The Habitats in the sangamchetty, Ravada, Aghora, Andhiyara kala, Paniyara kala and Gangori are in the slope of 35-42^0. Most of the area in this basin is covered in steep slope. Due to steep slope and week soil Pasture present in the area, the total area is washed out within few hours when the heavy rainfall happened in few minutes like Cloudburst. In 4th Aug 2012 the discharge from Narora dam is around 1.11 lakh cuses and increased 1 meter rise of rRver Ganga in Gangori area. The Danger mark of Ganga River is 113m but the water mark is Flowing reach to 112m. The visual representation of the sub-merged urban area in Uttarkashi Region near TilakBridge and Joshiyara area are shown in Fig.8

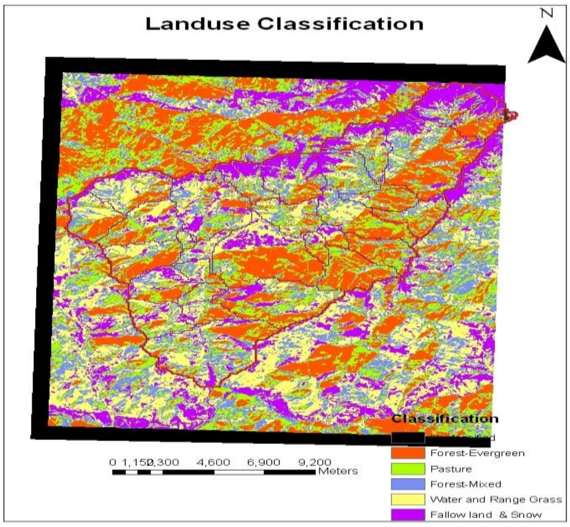

Fig.3 LandUse Map of the Study area

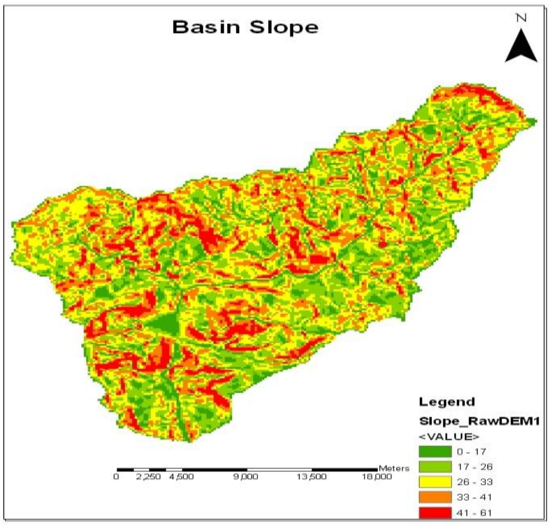

Fig.4 Slope angle map of the Study area

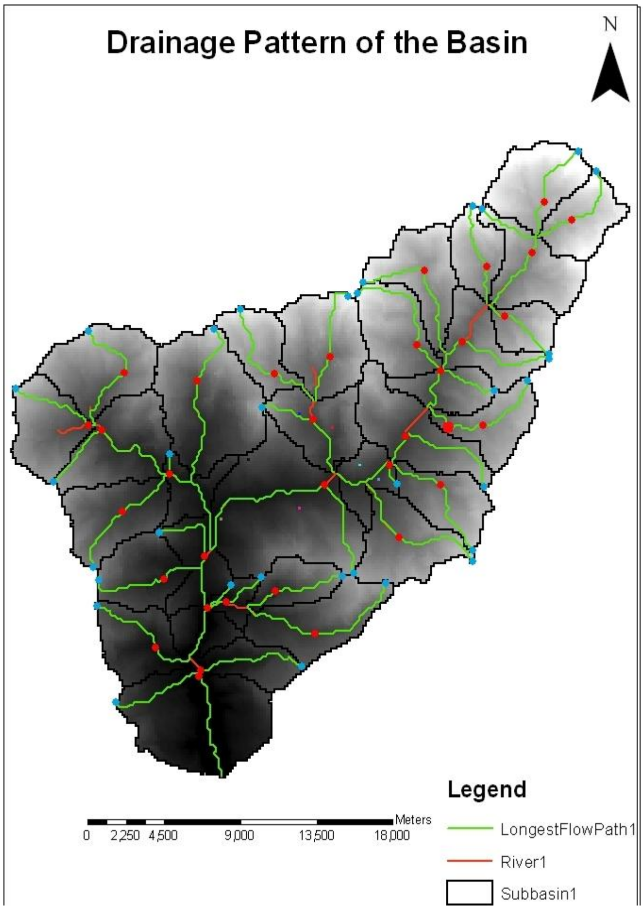

Fig.5 Basin Characteristics of the study area

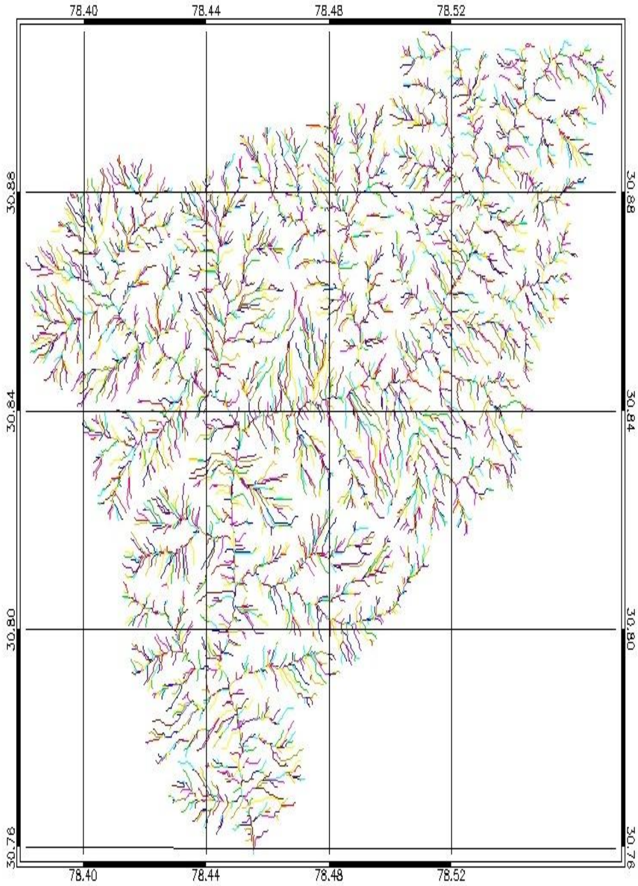

Fig.6 Evaluation of Stream order of study area in River tools

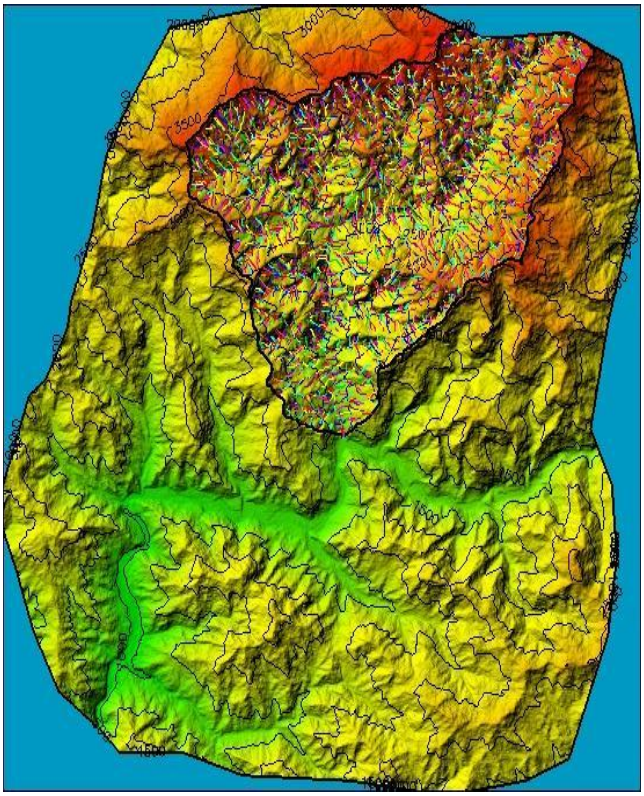

Fig.6 Elevation profile of the study area with contours

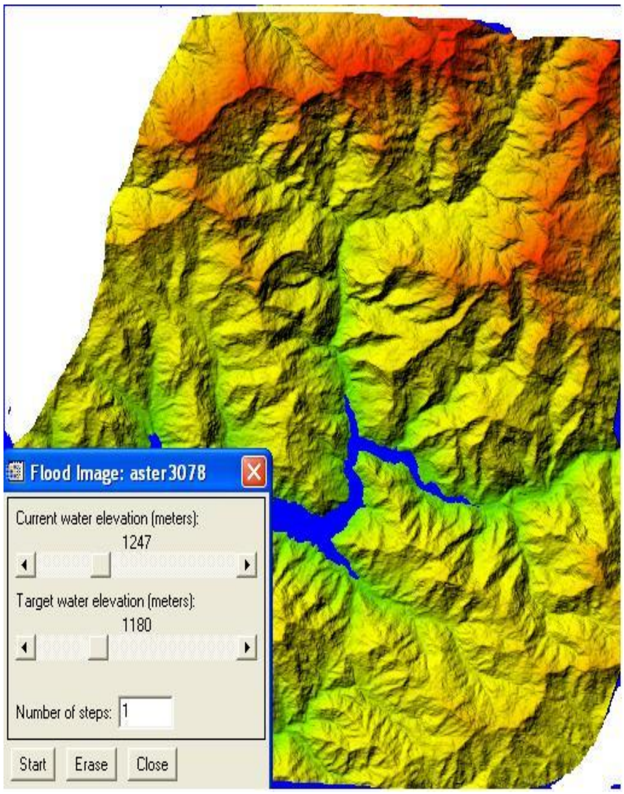

Fig.6 Visual representation of submerged area

Table 3. Characteristics of the AssigangaBasin

S.No	Basin Name	Max . Elev	Outlet Elev (m)	Area (Km^2)	Basin relief (km)	Pruning threshold	Strahler order	Longest channel length (km)	Total channel length (km)	Drainage density	Source density
1	Assiganga		1180	176.8 9	2.83	3.0	7	28.37	1101.86	6.228	17.55

Table 4 : Drainage characteristics of the Assiganga River

Stream order	Total Length (km)	Average Area (km^2)	Average Slope (m/m)	Average Relief (km)	Average Sinuosity	Average Drainage Density (Km^{-1})	Source Density (Km^{-2})
1	659.1982	0.0379	0.49124971	0.1147	1.0627	5.5265	35.8321
2	235.0611	0.1572	0.41884516	0.3387	1.0561	6.6553	23.4098
3	108.1992	0.7442	0.34345747	0.6395	1.0565	6.5414	19.7534
4	54.7023	2.5217	0.23727989	0.9453	1.0633	6.3561	18.9803
5	54.7558	12.1381	0.13596486	1.5615	1.0566	6.2811	18.3450
6	13.2826	57.0466	0.07790206	1.9659	1.0610	6.0348	18.0879
7	9.5002	155.6873	0.03763587	2.6436	1.0271	6.1887	17.6327

IV. CONCLUSION

GIS technique is being used widely in many engineering problems, which involves spatial data management. Likelihood occurrence of slope failures with respect to causative variables verified that slope and bedrock layering variables are found to be the most influential factors. Natural slope angle is the distinct pre-disposing factor for slope failures and maximum failures were found at slope angle of 40^0 within range of 35^0-60^0. Care should be taken when determining Structural and non-structural flood mitigation measures for flood hazard control in critical areas like Joshiyara and Sangamchetty. The analyses from RiverTool and GIS results give the planner and engineer a better understanding and visualization of the problem. Thus, its help them for selecting suitable location to implement development schemes in hilly terrain, as well as for adopting appropriate mitigation measures in unstable hazard prone areas.

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