Monitoring and Analysis of CloudBurst Region using Geomantic Techniques

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Abstract:

Cloudburst is an extreme form of rainfall, sometimes mixed with hail and thunder, which normally lasts no longer than a few minutes but is capable of creating flood conditions. This leads to flash floods/ landslides, house collapse, dislocation of traffic and human casualties on large scale. 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. When there are instances of cloudbursts, the results can be Flash Floods. In Himachal Pradesh and Uttarakhand, the flash-floods are mostly the result of cloudbursts. The cloudbursts are the result of combination of different factors like Land use/Land cover, steep gradient, deep valleys and geology of area. Cloudburst not only causes huge economic loss in the form of damage to houses, industries, public utilities, and property but also many human lives and of cattle heads are lost. Cloudburst in Assiganga Area, Uttarkashi region is Around 196.004 sq.km.The elevation Profile of the area varies from 3050m to 1600m. From the Slope Analysis the area Above Sangamchetty to Gangori lies in $35\text{-}42^0$. Due to heavy rainfall in short period the discharge from Narora dam is around 1.11 lakh cuses and increased 1 meter rise of river ganga in gangori area. The Danger mark of ganga river is 113m but the water mark is Flowing reach to 112m. 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. The consequence is that the magnitude of the impact of a disaster increases since it is dependent on the susceptibility of the land and the vulnerability of the society. The identification of cloudburst area is a warning system to relay information about Cloudburst could be placed in the settlements to help quick evacuation. Preparation of maps like Cloudburst areas, landslides, Floods and Flash floods maps are having an advantage for the prediction the intensity of damage.

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Index Terms— Clouburst, GIS, Aster DEM, LandSat Imagery, Flash Floods.

Introduction

Cloudburst is an extreme form of rainfall, sometimes mixed with hail and thunder, which normally lasts no longer than a few minutes but is capable of creating flood conditions. This leads to flash floods/ landslides, house collapse, dislocation of traffic and human casualties on large scale [1].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. When there are instances of cloudbursts, the results can be disastrous (e.g. Bombay cloudburst, 25th july2005 and Leh, 2010). The large water drops are fall down in the form of rainfall creates flashfloods and landslides. Flashfloods are extreme events that are sudden, severe and short lived. It is a sudden and often destructive surge of water down a narrow channel or sloping ground, usually caused by heavy rainfall. In Uttaranchal and Himachal Pradesh, the flash-floods are mostly the result of cloudbursts. The cloudbursts are the result of combination of different factors like Land use/Land cover, steep gradient, deep valleys and geology of area [2]. The Cloudburst problem is mainly during the months of June to September when the south west monsoon is in progress and snow is melting in the higher reaches. Cloudburst not only causes huge economic loss in the form of damage to houses, industries, public utilities, and property but also many human lives and of cattle heads are lost. The cloudbursts are happened when moisture laden air lifts with sufficient rapidity to form cumulonimbus clouds shedding water load with great strength and ferocity.

Indian climate is dominated by monsoons. Monsoon winds blow from cold to warm regions and blow from the land toward the sea in winter and from the sea toward land in the summer. The two monsoons in India are Southwest monsoon and Northeast monsoon. The Southwest monsoon takes the major part in India and Cloudbursts mostly occurs in monsoon season. Floods and flash floods are among the most catastrophic natural hazards in the world causing the largest amount of deaths and property damage[3]. Floods can influence many aspects of human life due to their destructive effects and create significant expenses on mitigation efforts. Flash floods risk assessment is one of the major roles in today's environment. Heavy rains, land-use change in basin areas and various engineering applications contribute to the magnitude and frequency of flood events. Human activities such as unplanned rapid settlement development, uncontrolled construction of buildings in general and major Landuse changes can influence the spatial and temporal pattern of hazards [4].The recent Work was done to investigate the stability of soil where areas of concern was targeted to sloping area or areas which were identified as prone to failure such as Cloudburst or erosions [5]. Nevertheless, activities such as land clearing, reclamation and rehabilitation too should be carried out only after a thorough study on impacts of soil erosion has been performed. These works should be followed by proper planning and management of land utilization which to be adopted at the very early stage of any proposal of land usage [6].

ENVI software solution is for data visualization, imagery orthorectification and georeferencing of the required information and its integration with GIS data. In ENVI the Decision Tree algorithm is used for joint analysis of various data (digital elevation model (DEM) – altitude, slope angle and direction; hydrogeological peculiarities – groundwater depth, the nature of soils; specific features of the vegetation cover) in order to identify areas subject to erosion processes and Natural hazardous areas. In this investigation we used ENVI and ESRI Arc GIS 10 for Georeferencing, Slope estimation, Reclassification and over lay operations.

Study Area:

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 Assiganga is one of the tributary for Ganga River and The Altitude of the study area ranges from 1600 to 3300 meters above sea level (ASTER DEM). The total area of the watershed is 196.004 sq. km. The Study Area is shown in Fig 1, Fig 2 and the Details of Cloudburst areas showed in Table 1. For every year thousands of pilgrims are going to Gangotri, badrinath and kedarnath etc. 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.

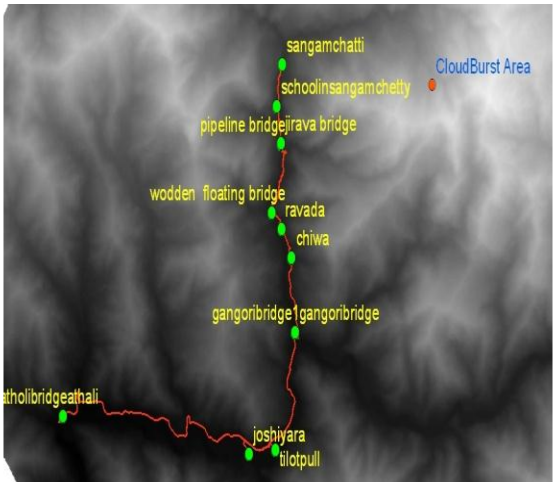


Figure 1: The Study Area Assiganaga of ASTER DEM

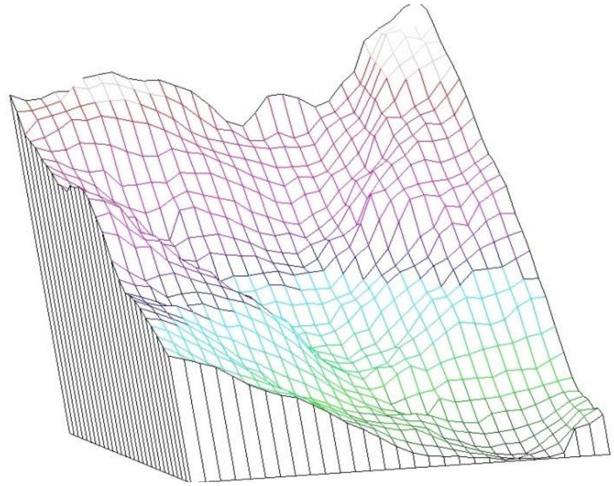


Figure: Surface Profile from Aster DEM for Assiganga Area

Data Sources:

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 for free from the USGS Global Visualization Viewer (GLOVIS). 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 which is showed in Table 2. From Disaster mitigation management center (DMMC), Dehradun the Cloudburst areas in Uttarakhand [7] are showed in Table 3.

Table 1: Details of Satellite data used in the analysis

Satellite Data	Date of acquisition	Spatial Resolution (m)
Landsat ETM+	03/09/2005	30
Google Earth Imagery	25/10/2005	

Table 2: Details of Elevation Data

Satellite Data	Resolution
ASTER DEM	30 meter

Table-3 Details of Cloudburst in Uttarkhand, 2012

Date	State	District	Effected Villages
05/07/2012	Uttarkhand	Uttarkashi	Asi ganga ghat, Charaghani, Andiyarakala, Phaniyarakala, Ravada
05/07/2012	Uttarkhand	Chamoli district	Beriya area
04/08/2012	Uttarkhand	Uttarkasi	Dayara bhugyal villge, Joshiyada, Gangori bridge
19/08/2012	Uttarkhand	Uttarkasi	Nuranu village,Mori area
14/09/2012	Uttarkhand	Rudraprayag	Timada, Sansari, Giriya, Chunniand, Mangali ,Premnagar and Juatok villages in Ukhimath area
14/09/2012	Uttarkhand	Bageshwar district	Kapkot near Almorah

Methodology:

By using Spatial Analyst tool in Arc GIS Software, a slope stability analysis was done and run through and every pixel in the basin having an area 196.815 sq.km. Where calculation from these DEM can produce a mapping of slope stability factors. By using infinite slope method, failure plane that is the interface between the rooted soil and bedrock were considered. From the slope stability analysis, two conditions were taken into consideration besides all other aspects such as soil parameters and contours; they were vegetation without land cover and with land cover.

From the Landsat ETM+ map we can actually identify:

- Basin Area coordinate
- Environment status
- HABITAT or land usage and

From ASTER DEM identified:

- Contours for the surface area.
- Elevation values.

A set of 10 land Use classes (Table 4), 5 slope types (Table 5) and 3 soil classes(Table 6) was defined in order to cover the natural variability on the study Area Assiganga in Uttarakashi district.

Table 4 : Types of of Land Use Classes in the Study area

S.No	CODE	Description
1	FRSE	Forest-Evergreen
2	FRST	Forest-Mixed
3	PAST	Pasture
4	RNGE	Range-Grasses
5	RNGB	Range-Brush
6	WATR	Water
7	SNOW	SNOW
8	A279	Rainfed
9	E279	Current fallow
10	D279	Double/Triple Surface Irri

Table 5: Types of Slope Range in the Study area

S.No	Range
1	0-5
2	5-15
3	15-25
4	25-45
5	45-90

Table 6: Types of Soil classes in the Study area

S.No	code
1	NRCS-07N0163
2	NRCS-82P0469
3	NRCS-91P0542

Analysis and Results:

In Analysis by considering the Factors like slope, Habitation and soil, the results could be seen as maps that will show the different categories of factor of safety derived from the analysis done through using slope analysis and GIS principles. From the Analysis the Results of Landuse, slope and Soil Classification area showed in Table 7, Table 8 and Table 9 respectively. 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 of the Assiganga is showed in Figure 6. 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 slpoe and week soil present in the area the total area is washed out within 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 river ganga in gangori area. The Danger mark of ganga river is 113m but the water mark is Flowing reach to 112m. The climate parameters are showed in Table 10.

Table7: Landuse Classification of Assiganga Area

1	FRSE	7349.94
2	FRST	2854.44
3	PAST	6654.96
4	RNGE	1189.89
5	RNGB	422.01
6	WATR	0.81
7	SNOW	452.79
8	A279	90.72
9	E279	25.92
10	D279	558.90

Table 8: Slope Analysis of Assiganga Area

S.No	Range (Degree)	Area (ha)
1	0-5	43.74
2	5-15	321.57
3	15-25	805.14
4	25-35	1838.70
5	35-90	16591.23

Table 9: Soil Classification of Assiganga Area

S.No	code	Area(ha)
1	NRCS-07N0163	12138.66
2	NRCS-82P0469	6756.21
3	NRCS-91P0542	705.51

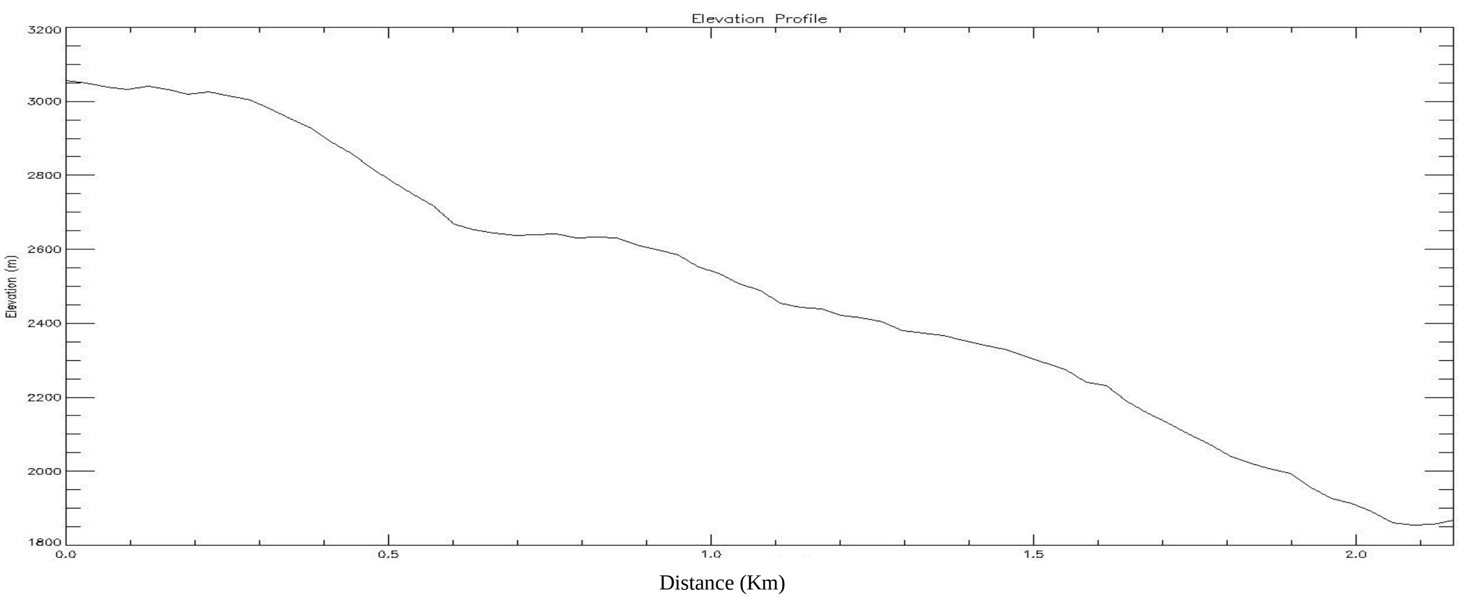


Figure 3: Elevation Profile of the study area

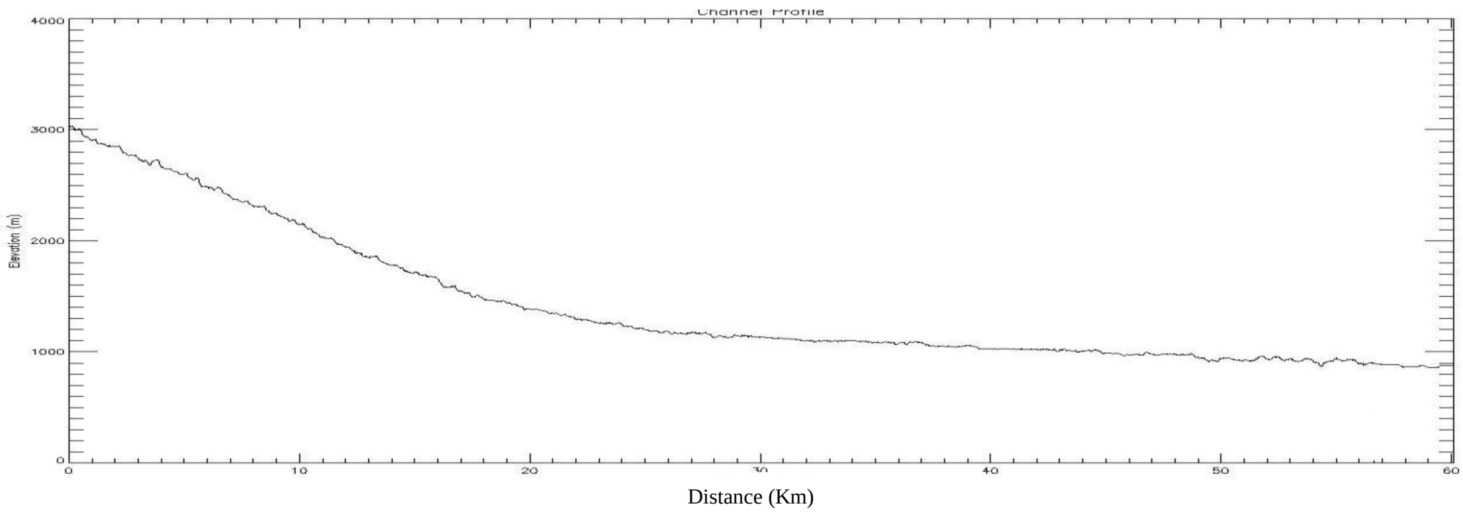
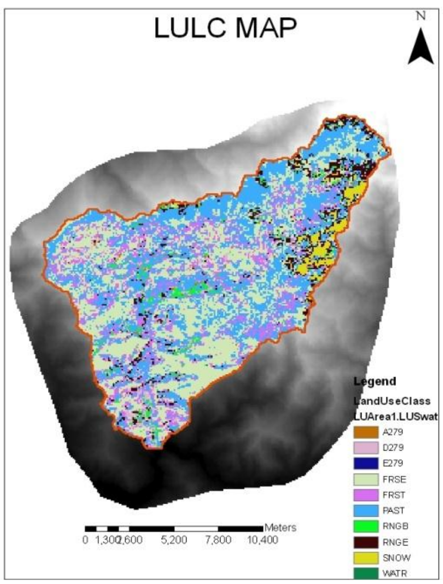
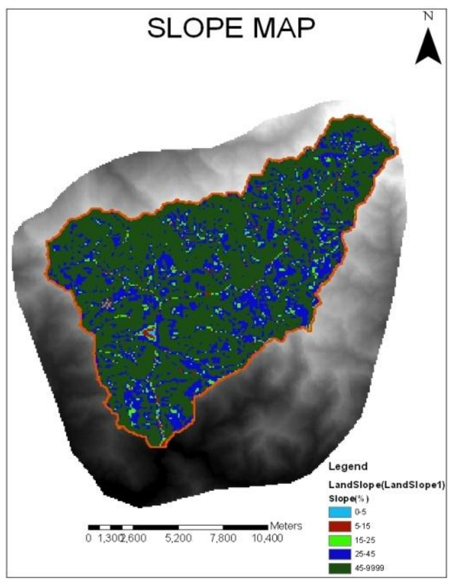


Figure 4: Channel Profile of the Assiganga Area





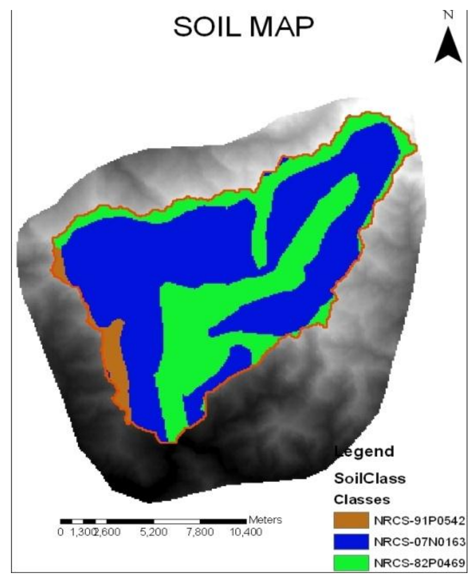


Figure 5: Landuse map **Figure 6: Slope map** **Figure 7: Soil map**

Table10: Climate Factors Behind the Cloudburst

Date	Max. Temp	Min. Temp	Rainfall	Cloud	Wind	Humidity
03/08/2012	26 °c	19 °c	19.2mm	64%	5 Mph	98%
04/08/12	23 °c	19 °c	30.7mm	100%	6 Mph	98%
05/08/2012	23 °c	19 °c	14.8mm	65%	4 Mph	84%

Conclusion:

The recent advent of Geographic Information Systems (GIS) and Remote sensing techniques have created an effective means by which the acquired data are analyzed for the effective monitoring and mapping of temporal dynamics of Natural Hazards like Cloudburst. Slope Analysis in Cloudburst Areas has been detected from Spatial Annalist Tool in GIS. A large number of researchers have taken advantage of remote sensing, GIS and GPS in their studies of Cloudburst. In this study Habitation, Slope Analysis and Soil classification can be mapped using Aster DEM and ArcGIS Tools. This study shows that the Slope Analysis and Loss of Habitation can be estimated using combination of GIS and remote sensing techniques. From the studies, it shows that GIS can be used to determine the slope stability, very convenient and easy to understand where prediction of failure can be seen on a single map. This will make the studies much more accurate if the information of soil data and vegetation are of true value or interpreted correctly through test and measurement being done on site.

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