Flood Simulation Modelling in Parts of Kundah River, the Nilgiris, Tamil Nadu

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***Abstract* - The Kundah river is one of the important rivers in The Nilgiris, Tamil Nadu, South India. The entire river is flowing on the steep slope hilly terrain. Some major reservoirs like Avalanche, Emarald and Kundah were constructed across the Kundah river and mainly used for generating hydroelectric power to fulfill the local domestic needs. The aim of this study is to simulate flood situation on one-dimensional model and identify the possible prone for flooding. In this simulation study, a river length of 6 Km. was taken on the downstream side of Avalanche Reservoir in Kundah river. MIKE 11 1D model was used for generating water profile surface of the study area. River feature and river cross-section were extracted from CARTOSAT1 DEM. The result obtained from flood simulation model shows that the flooding will affect between 2.70 Km. to 2.95 Km. stretch to a proximity of 250 m on right bank of Kundah river.**

Keywords: CARTOSAT1 DEM, River cross-section, MIKE11 1D model, Flood Simulation Study & Kundah River

1. INTRODUCTION

A flood is an overflow of water that submerges land surface and causes damage to human life and property. Mays and Tung (1992), Kyu-Cheoul Shim et. al. (2002) and Huaixiang Liu et. al. (2012)) have worked on the assessment of flood hazard and related problems.

Flooding is mainly caused due to heavy rain and subsequently causes an overflow of water from the River or Lake. In the ancient period, Floods were not managed well. This is because of lack of knowledge in storing the flood water / diverting the water in an optimized way so that the impact of flood is minimised. In the later stage, due to the construction large number of Dams and Reservoirs, impacts due to flooding has been under controlled and hence gradually decreased. However, some threats still rose due to dam breaking and flash flooding.

Dam breaking and flash flooding are interlinked and have one to one relationship with each other. These phenomena severely affect the infrastructures and lives on the floodplain of the river, generally downstream side. By developing a flood simulation of a dam breaking situation, the same will help to take decisions and prevent heavy loss to the lives and infrastructure. Geographic Information (GI) Technologies and flood numerical models like HEC-RAS, MIKE, SOBEK and ISIS were used to build the flood simulation models by various researchers. Morten Rung et. al. (2003), Vanderkimpen P. et. al. (2009), Kiran Yarrakula et. al. (2010) and Durga Rao K.H.V. et. al. (2014) have used various numerical models for flood simulation at different scenario.

2. STUDY AREA

The area selected for the present study is part of Kundah river in the hilly terrain of The Nilgiris, India. The Nilgiris is situated in the Western Ghats and The Nilgiris mountain is famously called as Blue Mountain. Kundah River originates from Avalanche and Emerald Reservoirs located in southern part of The Nilgiris. The river flow southeastward and joined with Bhavani river. In this simulation study, a river length of 6 Km. was considered for flood simulation from the downstream side of Avalanche Reservoir. Along this river stretch, six habitations namely Inbasagarnagar, Kuttimaninagar, Nehrukandy, Nehrunagar, Periyarnagar and Surendranagar are existing. These habitations were identified within the proximity of 500 m. from the centre-line of the Kundah river. In these six habitations, Nehrunagar and Nehrukandy are situated very close to the river bund (Fig. 1).

3. DATA USED

In order to georeference various data to be used for this study, Ground Control Point (GCP) survey was conducted. As many as 54 GCPs were captured in the field using single frequency Differential Global Positioning System (DGPS). These 54 GCPs were post-processed for achieving high accuracy using trimple post-processing software. The satellite imagery namely, CARTOSAT1 panchromatic stereo data with 2.5 m. resolution was rectified using the post-processed GCPs. Fine resolution Digital Elevation Model (DEM) was generated from CARTOSAT1 panchromatic stereo data. Apart from these, centre-line of the river and cross-section data were extracted from fine resolution DEM data and used for this study. KiranYarrakula et.al. (2010) and Durga Rao K.H.V. et. al. (2014) have mentioned that DEM is very much useful for flood simulation study.

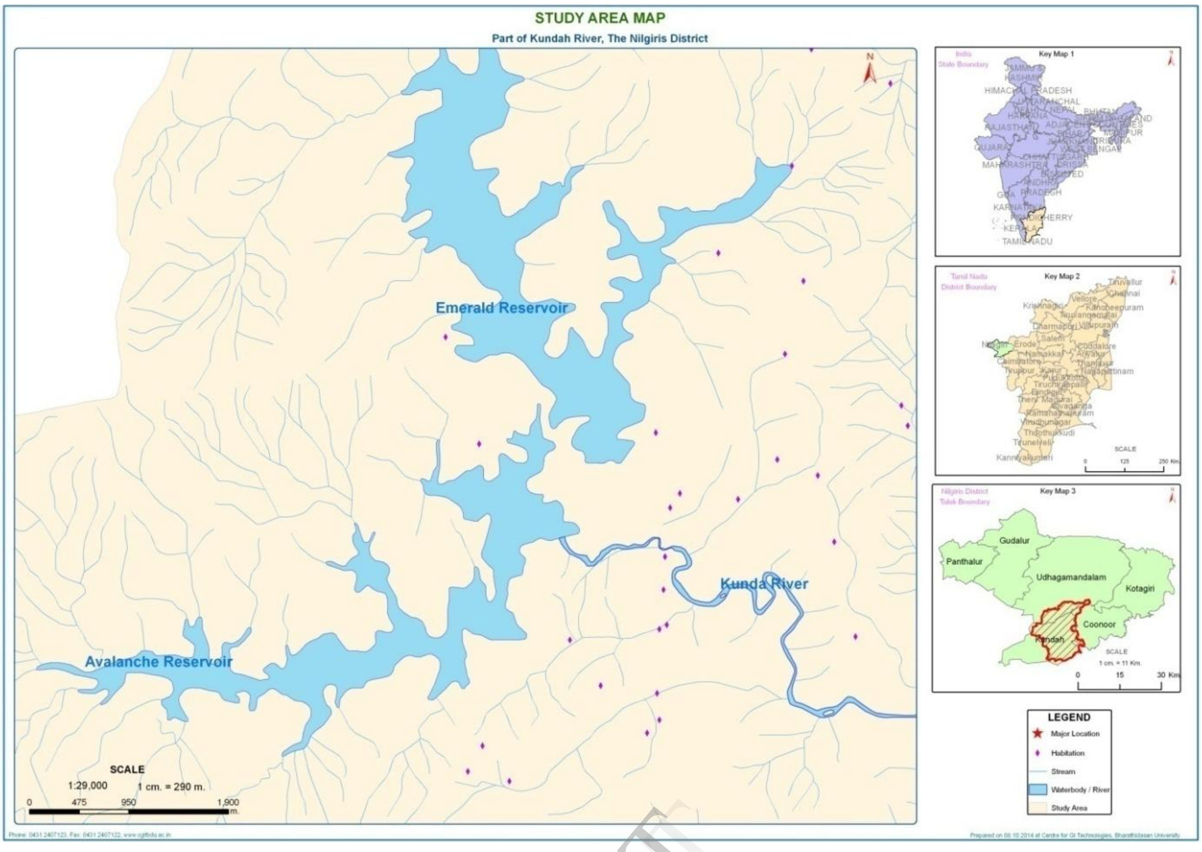
STUDY AREA MAP
Part of Kundah River, The Nilgiris District
Emerald Reservoir
Avalanche Reservoir
Kunda River
SCALE
1:29,000
1 cm. = 290 m.
0
475
950
1,900
m.
Key Map 1
Key Map 2
Key Map 3
Gudalur
Panthalur
Udhagamandalam
Kotagiri
Coonoor
Kundah
LEGEND
Major Location
Habitation
Stream
Waterbody / River
Study Area

Fig. 1

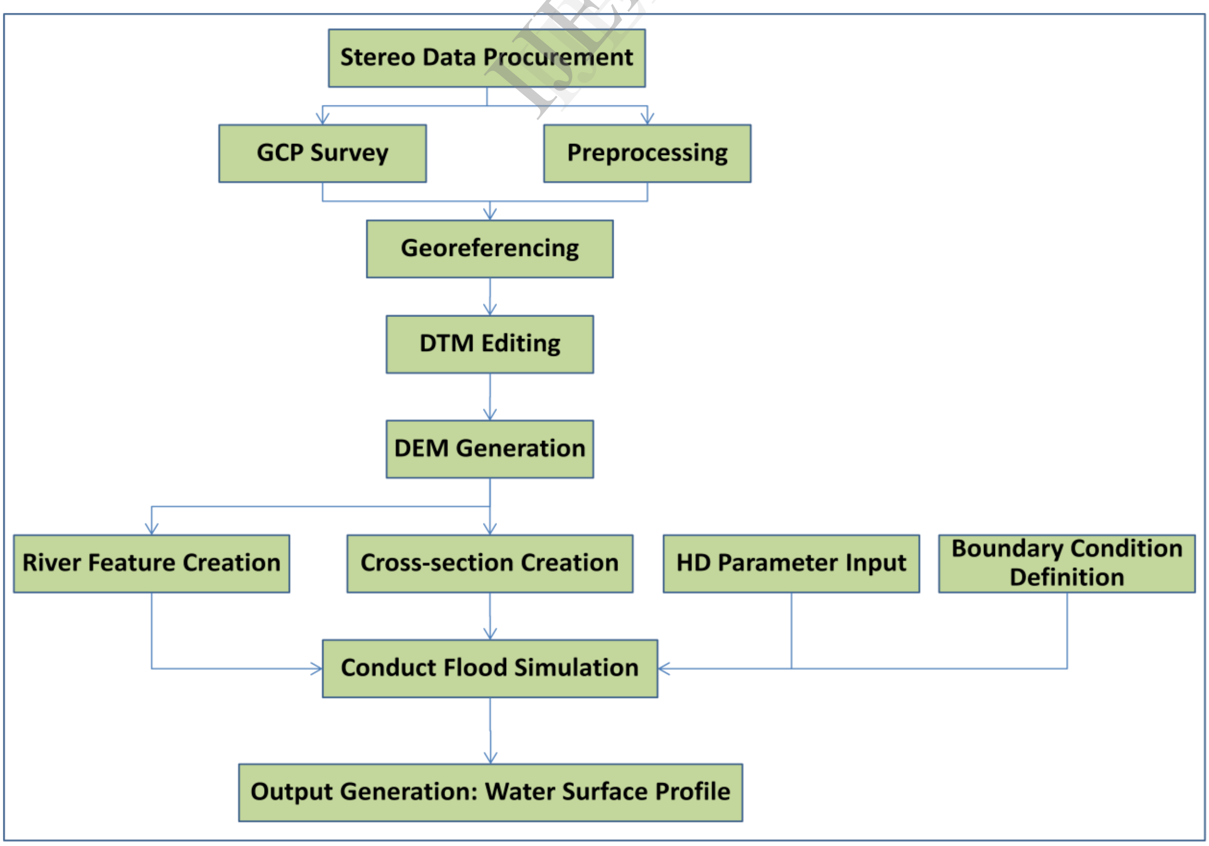
Stereo Data Procurement
GCP Survey
Preprocessing
Georeferencing
DTM Editing
DEM Generation
River Feature Creation
Cross-section Creation
HD Parameter Input
Boundary Condition Definition
Conduct Flood Simulation
Output Generation: Water Surface Profile

Fig. 2

4. METHODOLOGY

The methodology adopted for the present study is given below in Fig. 2.

MIKE11 1D model developed by Danish Hydraulic Institute (DHI) was used for the simulation of flood in the hilly terrain of Kundah river. The following steps were used to execute MIKE11 1D model:

Step 1: River Network data was generated from CARTOSAT1 DEM.

Step 2: River Cross-section data in 10 river locations was generated from CARTOSAT1 DEM.

Step 3: The input for Boundary condition was given in three modes as below:

a) **Inflow:** Inflow is nothing but discharge of water at zero chainage. The inflow data at zero chainage of the river was given at different time interval.

b) **Outflow:** Outflow is nothing but the discharge of water at the end chainage and in this case 6th Km. from zero Km. chainage. The outflow data at 6th Km. chainage of the river is calculated by the MIKE11 model using cross-section data given in Step 2.

c) Parameter of Dam Break structure: Dam location, crest length, crest level, reservoir water level and failure mode are given as input.

Step 4: Inputs like initial condition, bed resistance, wave approximation, etc. were given as Hydrodynamic (HD) parameter to the model.

The centre-line of the river and cross-section derived from DEM of CARTOSAT1 stereo and other parameter as mentioned above were given as input in the MIKE11 1D model. While running the model with these inputs, water surface profile was calculated. The water surface profile (Figue.3) was created by simulating a discharge at an interval of four hours for three days continuously. The model was executed based on cross-sectional averaged Saint-Venant equation method of one-dimensional model.

5. RESULTS AND DISCUSSION

The results of water surface profile modeled through MIKE11 1D during the starting time of first day is shown in Figure 3. The height of the dam structure, Bund wall on the right (green) and left (blue) banks are also shown in the figure below. The red line in the graph indicates the maximum expected water level throughout the chainage.

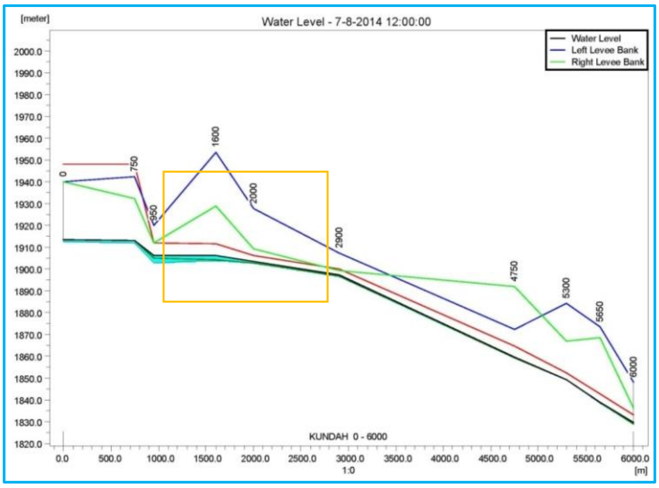

Fig. 3

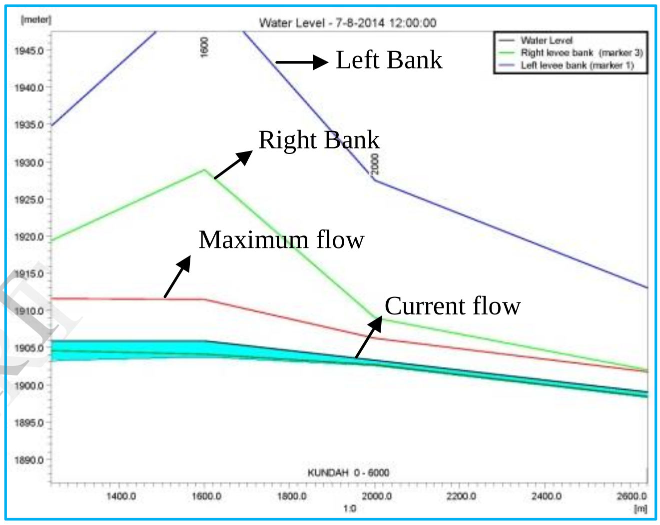

Fig. 3 (Zoom)

In the given boundary conditions, if the water continuously flown in to the dam (Figure 4), Maximum Water Level (MWL) is attained at 21.15 hours on the first day (i.e. after 9 hours 15 minutes from the time of start). At this stage, as the maximum water level is reached, unexpectedly water starts overflowing from the dam. In the beginning stage, volume of water flowing out of the dam was minimal. After some time, due to erosion of earth, the outflow is increased enormously and volume of water is rapidly flown into the river. At this situation, it was observed from the model that the water flow along the river was still maintaining it safe level throughout the entire stretch. It is further noticed, that the water level on the river is still getting increased.

Figure 5 shows that, at 8.15 Hrs of the second day (i.e after 20 hrs and 15 minutes from the time of start), at a chainage of 2.90 Km. from zero chainage, the right side bund is not capable of withstanding the flood condition and hence water starts overflowing at this location. Simultaneously, the inflow of water to the dam is getting increased and attains

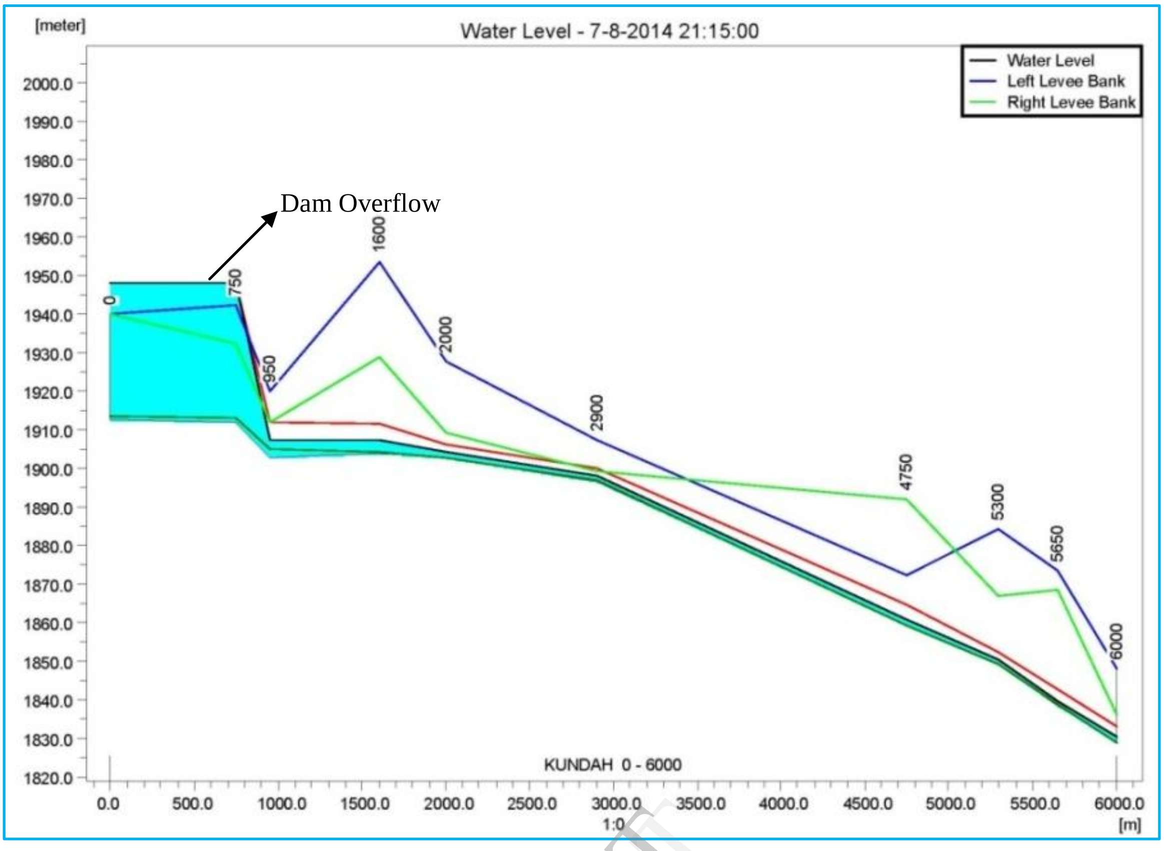
[meter]
Water Level - 7-8-2014 21:15:00
Water Level
Left Levee Bank
Right Levee Bank
Dam Overflow
2000.0
1990.0
1980.0
1970.0
1960.0
1950.0
1940.0
1930.0
1920.0
1910.0
1900.0
1890.0
1880.0
1870.0
1860.0
1850.0
1840.0
1830.0
1820.0
0
750
950
1600
2000
2900
4750
5300
5650
6000
KUNDAH 0 - 6000
0.0
500.0
1000.0
1500.0
2000.0
2500.0
3000.0
3500.0
4000.0
4500.0
5000.0
5500.0
6000.0
1:0
[m]

Fig. 4

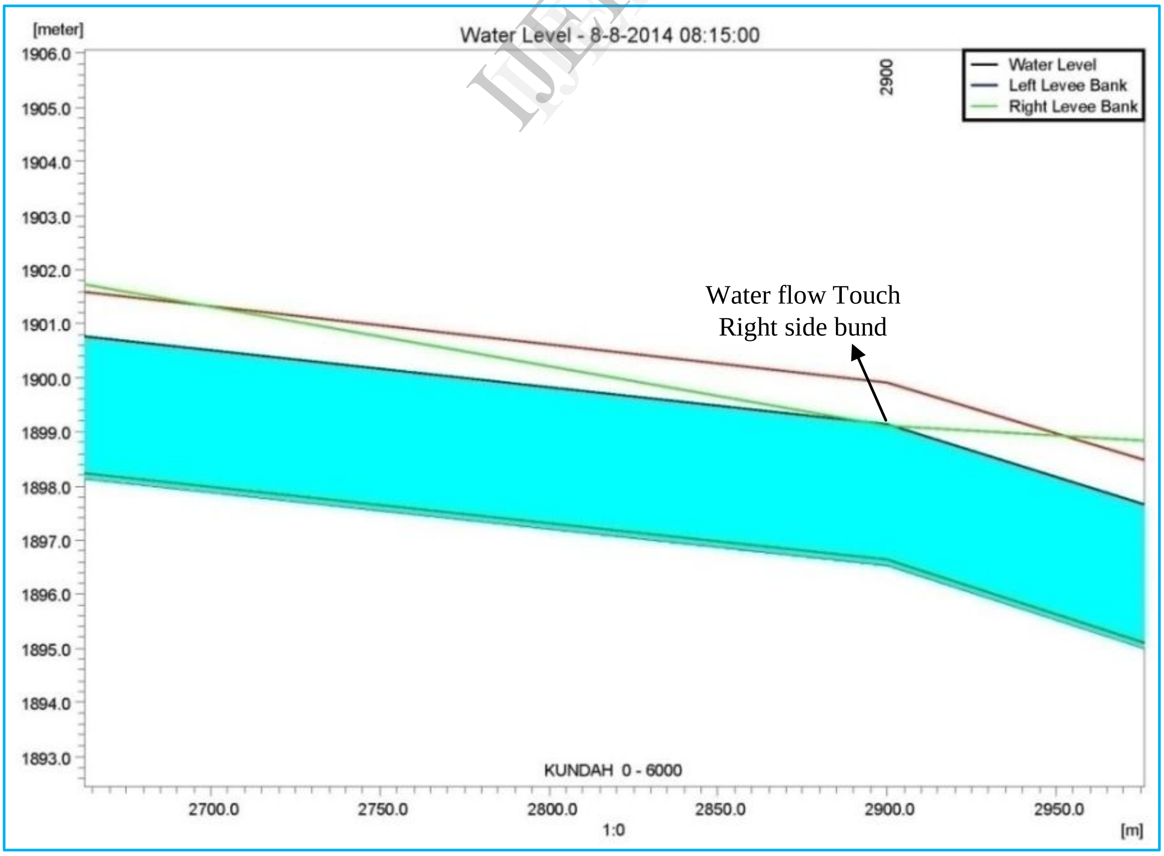
[meter]
Water Level - 8-8-2014 08:15:00
Water Level
Left Levee Bank
Right Levee Bank
2900
Water flow Touch
Right side bund
1906.0
1905.0
1904.0
1903.0
1902.0
1901.0
1900.0
1899.0
1898.0
1897.0
1896.0
1895.0
1894.0
1893.0
KUNDAH 0 - 6000
2700.0
2750.0
2800.0
2850.0
2900.0
2950.0
1:0
[m]

Fig. 5

inflow of 3000 m^3/s at zero chainage. Hence, the outflow was very high towards the downstream side of the dam.

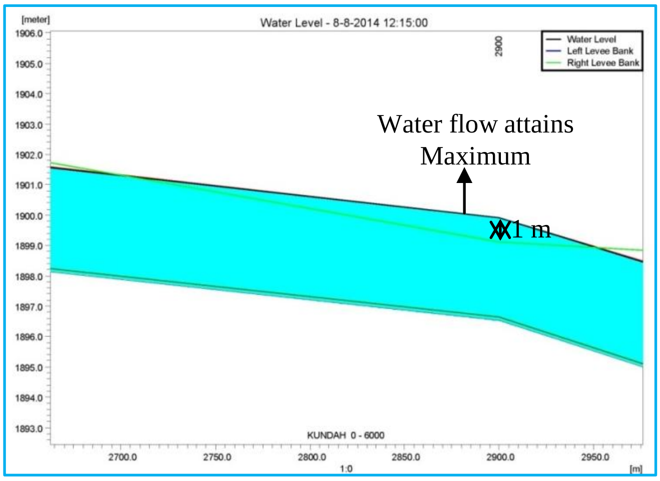

Fig. 6

Due to this, the outflow along right bund of the river, that is between 2.70 Km. and 2.95 Km. flood water spreads over the distance of 0.25 Km. It was also observed that water flown over the river bund to the maximum height of 1 m at 2.90 Km. chainage by around 12.15 hours of second day (i.e after 24 hrs and 15 minutes from the time of start). From the results, it was also noticed that the flooding situation is continuously maintain to the tune 8 hours duration. Due to the overflow at 2.90 Km. chainage, the nearest habitation namely Nehrukandy located at 350 m. proximity is heavily affected. On the second day, at 16.04 hours (i.e after 28 hrs and 4 minutes from the time of start), the flood completely stopped and water level on the river is slowly decreased on the third day by maintaining its force in control level and water flow was normal within the river bund.

6. CONCLUSION

The results obtained from flood simulation study using MIKE11 1D model is giving clear picture about inundation scenario of flood water for 3 days. And this can be modeled for any number of days with proper inputs. In the present study, when water uncontrollably overflows from Avalanche Reservoir, the flooding affects between 2.70 Km. to 2.95 Km. stretch to a proximity of 250 m. Further, the nearest habitation namely Nehrukandy located at right side bund of the river is the worst affected habitation. The MIKE11 1D model is found to be useful to analyse the simulation of probable flooding situation on 6 Km. stretch of the Kundah River.

REFERENCE

[1] Durga Rao K.H.V., et al. (2014), Kedarnath flash floods: a hydrological and hydraulic simulation study, Current Science, Vol. 106, No.4, Feb. 2014, pp 598-603.
[2] Huaixiang Liu, Yongjun Lu and Zhaoyin Wang (2012), GIS Approach of Inundation Analysis in the Dongjiang (East River) Drainage Area, Procedia Environmental Sciences 12 (2012), pp 1063-1070.
[3] KiranYarrakula, Debasis Deb and Biswajit Samanta (2010), Hydrodynamic Modelling of Subernarekha River and its floodplain using Remote Sensing and GIS Techniques, Journal of Scientific & Industrial Research Vol. 69, July 2010 pp 529-536.
[4] Kyu-Cheoul Shim, Darrell G.Fontane and John W.Labadie (2002), Spatial Decision Support System for Integrated River Basin Flood Control, Journal of Water Resources Planning and Management, Vol. 128, No.3, May/June 2002 pp 190-201.
[5] Mays.L and Tung Y. (1992), Hydrosystems Engineering and Management, McGraw-Hill, New York.
[6] Morten Rung and Kim Wium Olesen (2003), Combined 1- and 2-Dimensional Flood Modelling
[7] Vanderkimpen P., Melger E. and Peeters P. (2009), Flood Modelling for risk Evaluation – a MIKE FLOOD vs. SOBEK 1D2D benchmark study, Flood Risk Management Research and Practice – Samuels et al. (eds) 2009 Taylor & Francis Group, London ISBN 978-0-415-48507-4.