International Journal of Scientific & Engineering Research Volume 4, Issue 5, May-2013
ISSN 2229-5518

# Application of ASTER DEM in Watershed Management as Flood Zonation Mapping in Koyana River of the Western Ghats.

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**Abstract**— Most of the natural hazards result from the potential for extreme geophysical events, such as floods, to create an unexpected threat to human life and property. When severe floods occur in areas occupied by humans, they can create natural disasters that involve the loss of human life and property plus serious disruption to the ongoing activities of large urban and rural communities. Flood hazards results from a combination of physical exposure and human vulnerability reflected by key social-economic factors such as the number of people at risk in the floodplain or low-lying zone, the extent of flood, and the ability of the population to anticipate and cope with hazard. In the present study flood level mapping of Koyana river basin has been carried out along with the ASTER GDEM based layers derived in ILWIS software developed by ITC, Netherlands. Also, the present effort tries to co-relate the output from ASTER DEM analysis with the flood hazard related information generated from various other RS and GIS data sources.

**Index Terms**— Aster, FCC, DEM, Georeferance, Geocoding, GIS, GPS, Koyana, LANDSAT, NDVI.

## 1 INTRODUCTION

THE Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) was developed jointly by the Ministry of Economy, Trade, and Industry (METI) of Japan and the United States National Aeronautics and Space Administration (NASA). The ASTER GDEM was contributed by METI and NASA to the Global Earth Observation System of Systems (GEOSS) and is available at no charge to users via electronic download from the Earth Remote Sensing Data Analysis Center (ERSDAC) of Japan and NASA's Land Processes Distributed Active Archive Center (LP DAAC). The ASTER GDEM is in GeoTIFF format with geographic lat/long coordinates and a 1 arc second (approximately 30 m) grid. Here the effort has been made to derive many GIS layers like extracted contour, drainage, various slope maps for the slope analysis, flow direction map and flow accumulation map and moreover by using the ASTER GDEM as base, the stereo pairs of satellite imageries have also been extracted. This extracted information can efficiently be used for further hydrographic calculations and applications. The area selected for this basic data generation belongs to the part of Koyana River, which is the important right tributary of Krishna River in its upper basin of western Maharashtra. Aster GDEM, having the accuracy level higher than the DEMs generated from the interpolation of the contours from S.O.I. toposheets, are emerging as a very effective tool for a planning engineer for the decision making at strategic levels especially in the areas of watershed management,flood or landslide hazard zonation mapping and it's vulnerability assessment, infrastructural development planning etc. The present effort tries to co-relate the output from ASTER DEM with the flood hazard related data generated from IRS 1D PAN data.

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## 2 STUDY AREA

The Koyana River, fifth order perennial stream basin which is about 119 km. in length. The basin is developed in the uppermost reaches of the drainage system of the Koyana River, in Satara district of Maharashtra and is included with in the survey of India topographic sheet no.47G/11. The study area is lying between the latitude $17^0$ 01' 55.71N $73^0$ 01'39.10E and longitude $17^0$ 17' 23.83N $73^0$ 39' 53.26E The Koyana River collects its water from the Koyana Dam Constructed at Deshmukhwadi, Tal-Patan, Dist-Satara.and it's tributaries Kera, Morna and Wang. Also from the Sahyadri ranges on both side of Koyana river and drains in an area of about 120sq.km.The important townships present in the area are Helwak, Yerad, Patan, Navarasta, Marali Diwashi, Malharpeth, Navdi, Mhopre, Tambve, Supne, Karad etc. The area under study experiences semiarid to sub humid climate. During the period from June to October it receives heavy rainfall, the annual rainfall being in excess of 2000 mm in Patan Tahsil and the rainfall amount drops to less than 600 mm in Karad Tahsil. The summer is dry with maximum temperature reading up to $38^0$ C to $40^0$ C.

Fig.No.1. Location of the Study Area.

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## 3 OBJECTIVES

In the present study flood level mapping of Koyana river basin has been carried out along with the ASTER GDEM based layers derived in ILWIS software developed by ITC, Netherlands. Flood zonation map, with the help of available flood level map from Koyana dam authority, has also been generated. ASTER GDEM is in GeoTIFF format with geographic lat/long coordinates and a 1 arc second (approximately 30 m) grid. Here the effort has been made to derive many GIS layers like extracted contour, drainage, various slope maps for the slope analysis, flow direction map and flow accumulation map and moreover by using the ASTER GDEM as base the stereo pairs of satellite imageries have also been extracted. The generated stereo pairs are displayed in the form of anaglyphs that help in easy on screen planning or other digitization operations. This extracted information can efficiently be used for further hydrographic calculations and applications.

## 4 METHODOLOGY OF GENERATING LAYERS

The methodology adopted for the flood hazard zonation mapping in the study area, includes the various geoinformatical tools comprising geographical information system (GIS) technology and the satellite remote sensing (RS) techniques. The guideline provided by NNRMS course (Indian Institute of Remote Sensing, Four calidas road Dehradun). Study materials and the guidelines provided by the Koyana authorities have been adopted for present study. The generated RS layers have been interpreted by the conventional photo recognition elements or image interpretation keys along with the generated GIS data base for the decision making i.e. related to the flood management and mitigation techniques.

### 4.1 Preparation of the base map

The survey of India topographic map in 1:50000 scales with 20m contour interval in a digital format have been used as the basic source of the spatial information of study area. The manually prepared flood level map provided by the Koyana dam authority has also been used as a base map after converting the same into digital format. The Landsat seven TM data has been procured from the web source for band four (0.77-0.90µm), band three (0.63-0.69µm) band two (0.52-0.60µm) as the same spectral resolution is used in the creation of standard false colour composite imagery (Std.FCC)

The 5.6m spatial resolution pan data has been purchased from National Remote Sensing Center, Balanagar, and Hyderabad in standard IRS data format. Instead of the conventional method of interpolating the digitized contour and getting the DEM. To avoid or to minimize the cartographic errors, 1m DEM of the study area has been procured from web source. It has been generated by the aster RADAR; the microwave based active remote sensing system.

The mobile handset having the offline GPS facility has been specially procured for the ground truthing of web based and generated RS&GIS layers. It has been found to be equally effective tool in comparison with the routine GPS handset available in the market.

### 4.2 Preparation of Thematic layers

The topographic maps those were in the tiff. Format have been 'imported via geogateway' tool in the ILWIS environment and after making their colour composite the required sub map were extracted and with the help of glue operation, maps were glued in a single georeference. WGS84 related co-ordinate system have been assigned to the map with the help of tie point having known co-ordinates. Koyana River has been digitized from the generated base map. The flood level map provided by the Koyana authority have also been imported and glued in a single georeferance by the same way as that of topographic map. Geocoding and Georeferencing of this map was carried out from the reference of earlier base maps.

H.F.L. for 2,55,000 cusecs discharge from Koyana dam segment has been digitized in the value domain and thus segment available flood data was brought in the digital format. ASTER Radar 1m DEM has been used for further analysis. A sub map of ASTER data was extracted that covers both Krishna and Koyana river basins up to Karad city fig.no.2. It has been found thatafter overlaying the 2,55,000 cusecs H.F.L.on ASTER DEM it covers more or less the elevation of 600m.Keeping this in mind a 600 contour was extracted from ASTER DEM by the slicing operating. ASTER DEM was sliced for elevations below 600 and elevation above 600.The generated sliced raster data was vectorized to be converted to a polygon map again a polygon map was converted to a segment layers that was edited in value domain, all unwanted segments were deleted and only the 600 contour from Koyana dam to Karad was retained and given the value of 2, 55,000 cusecs as H.F.L. map Fig.No.4. This layer matches with the layer provided by Koyana authority from the same layer a polygon boundary map was digitized along the river banks to define the polygonal study area.

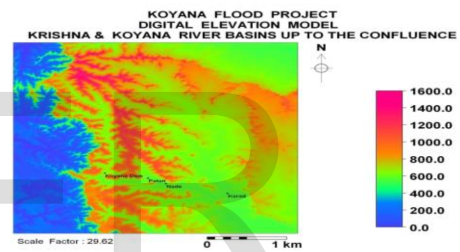


Fig.No.2. Digital Elevation Model of Krishna and Koyana River. Basin.

ASTER DEM was operated for fill sink so as to get the continuous flow direction and flow accumulation maps. Flow direction map was prepared by the ILWIS command and from the generated flow direction map the flow accumulation map was prepared .Each pixel in a flow accumulation map indicate the total no. of pixels from the rainfall data. The total volume of water (assuming zero percolation loss) can be calculated. The area below 600 R.L. was used after converting it to polygon and raster to extract the DEM through the boundary of study area and the extracted DEM was used for further analysis. After applying df dx and df dy filters the East-West and North South slopes were extracted respectively and with help of standard command slope percentage map, slope map in degrees and slope aspect map and slope shape map were prepared. Anaglyph of PAN data shows 3d model of the study area, derived from Aster DEM.

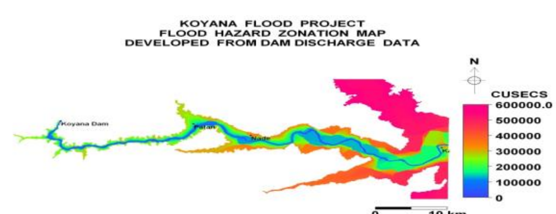


Fig.No.3.Flood hazard Zonation Map.

International Journal of Scientific & Engineering Research Volume 4, Issue 5, May-2013
ISSN 2229-5518


Fig.No.4 High Flood Level at 255000 cusecs.

The slope percentage map was sliced to get the IMSD slope classification and slope degree map was sliced to get the Youngs slope classification of the banks of Koyana River. Slope aspect map was sliced into eight conventional directions and slope shape map was sliced to obtain the concave, convex straight slope data. A LANDSAT 7TM data having 30m spatial resolution has been used to obtain a standard FCC & further land cover analysis. The three bands viz. band four( 0.77-0.90µm),band three(0.63-0.69µm) band two(0.52-0.60µm) imported seperated in the ILWIS environment after ensuring the proper geocoding, georeferanceing and the WGS 84 co-ordinate system to this image data. A standard false colour composite was prepared by Ilwis command a polygon boundary of study area was added on the FCC to get the lower left and upper right co-ordinate that are useful for the sub map exctraction. From the full-screen of the Landsat seven TM data the required submaps were extracted Fig. No.5. A segment of mainstream of Koyana River was digitized with the help of Landsat standard FCC.

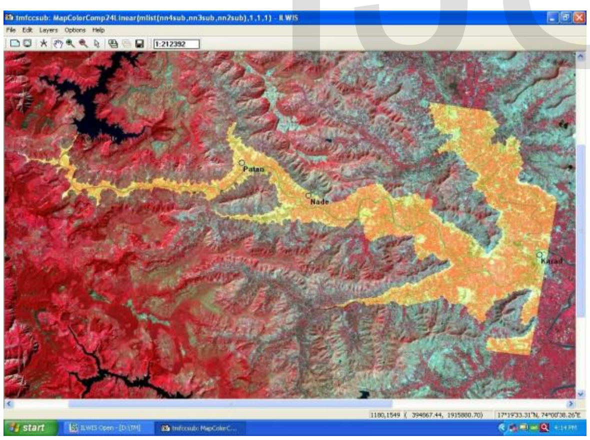

Fig. No.5. Spreading of water in case of dam Failureon Landsat TM Data.

A beautiful technique of band ratioing was used in the supervised classification of Landsat data as a part of band ratioing technique. The three pseudo-NDVI's (Normalised differ are Vegetation Index map). Three NDVI's were created b using band 4-band 3, band3-band2, and band4-band2 combitations. A sample sets was prepared by training the pixel of FCC for water vegetation and barren land. The same sample set was used to classify the mapset of NDVI's and thus the land cover map has been prepared after the supervised classification. The operated ILWIS command. IRS 1D pan data procured from NRSC was imported after converting it into ILWIS data format. A new co-ordinate system was assigned to the pan data which is related to the co-ordinate of Landsat of Landsat seven and aster data. After adding the layer earlier H.F.L segment, the totally new flood levels were digitized for 2, 55,000 cusecs and for 2200 cusecs, 93000 cusecs.

It is assumed after the past experience that during the heavy rainfall the 93000 cusecs discharge from koyana dam along with additional discharge of tributary like Kapana, Kera, Morana and Wangna discharge flows without any spill out from the narrow flood plains around the mainstream therefore the additional segments for 2200 plus tributaries discharge and 93000 plus tributeries discharge were digitized. Flow accumulation map was used to calculate the additional discharge from each confluence point of tributary with Koyana mainstream. Thus the flood level segment map becomes ready for further analysis.

The flood level map, prepared in value domain was interpolated and digital flood discharge model was created Fig.No.3. If IRS 1D pan or any geocoded, georeferanced high resolution satellite data is overlain on flood discharge model then only with a single click at any specified point on the imagery the discharged value in cusecs for which the same point to on the ground shall be inundated is displayed. This map can be easily be used for the zonation of flood level. Here in the present study the flood discharge model has been sliced into eight flood hazard zones .This layers along the interpretative aspect of the satellite data can be used for the assessment of degree of hazard and vulnerability condition along both the banks of Koyana River.

## 5 INTERPRETATIONS AND ANALYSIS OF GIS LAYERS

Koyana basin has steep abutements slopes on both the banks.

Both the banks are marked by steep hills form Koyanagar to Karad.The main stream has been developed, eroding the compact massive basaltic rocks .Therefore there is no chance of chaning the course of river, as that of river of north India. Most of the agricultural lands are developed after leveling. The considerable foothill slopes. The main stream volume and depth is considerably large with respect to the cusecs discharge from dam. This itself minimizes the flood hazard. Flood hazard is limited to certain area of Helwak, Patan and the near bank villages before Karad in extrem monsoon conditions though; the dam discharge and the contribution from tributaries are too high. The river is not much flood prone because of the high carrying capacity of the river itself. Flood related constructions like, gabian wall, retaining wall, increasing height of bridges, counterfort retaining wall (near Patan) etc. may help to reduce the vulnerability at the particular few places.

## 6 CONCLUSION

The use of flood models can help to prevent undesirable side effects of the developments and can assist in implementing effective mitigation measures. This could help in avoiding the event like a flood turning into a disaster because of unwise land use. Further more the visualization power of flood simulation will help to bridge the gap between scientific community and responsible authorities. For non experts it is usually hard to imagine what could be the extent of a potential of flood. Simulation can be a valuable communication to visualize the flood hazard in terms of magnitude, area affected and return intervals. The integration of flood hazard, the vulnerability and value of the various land use units into flood risk assessment is crucial. However, it can be safely stated that high resolution images will play a key role in the flood risk analysis. The effort were made for flood forecasting, flood plain zoning and disaster preparedness

International Journal of Scientific & Engineering Research Volume 4, Issue 5, May-2013
ISSN 2229-5518

for the settlement in Koyana river basin through the remote sensing data interpretation and GIS data base were generated after vector digitization and raster analysis.

It is attempted to demonstrate the utility of RS and GIS technique in flood risk assessment study especially in areas which are having steep relief inaccessible from conventional survey point of view. In this project the study of Koyana river basin is carried out. Koyana river basin is having very high relief and the river is flowing through straight slope. After the Patan volume of the Koyana River mainstream george is large enough so that the most of the flood discharge through Koyana dam is carried without causing the flood condition. The slope maps created in the GIS environment have indicated that the steeper slope are very common on the both the bank of Koyana river with high basaltic rock outcropping.

It is also observed from the DEM, which is generated after superimposing the contour, confirmation from the ground truthing field checks, and also from the verification of the past records that, Sangamnagar Bridge gets submerged every year at 30000 cusecs discharge from the Koyana dam, which paralyses the normal life of that area and disturbs Konkan borne traffic on SH-78. It is required to construct bridge which will non-submersible during the flood. When discharge from the Koyana dam is more than the 90000 cusecs then flood situation is created in and around the Patan town. If the discharge is further increases which disturbs normal life, hence to avoid the damages due to flood and spreading of the water in the Patan, it is necessary to construct sound retaining structures like gabbion wall, retaining wall etc. At Nisre it is also observed erosion of soil strata on the bank of the river due to flashing flood, it is necessary to provide protective measures such as gabbion wall and pitching of the river bank. Karad is an important city in western Maharashtra; It is an educational hub with increasing industrial and commercial activities. It is also gateway to Konkan and hence Karad has its own important position on the map of India. However Shukrawar peth area of Karad observes the floods even as the small discharge of 1, 42,000 cusecs. It is likely the river bank of Koyana and Krishna will get eroded due to flashing floods; to avoid these type of the damages it is necessary to construct the retaining structures such as gabion wall in the Shukrawar peth and Somwar peth of Karad.

It is observed that ASTER GDEM is an effective tool for many applications and has potential benefits in planning against flood disaster management and mitigation. ASTER GDEM is having the accuracy level higher than the DEM generated from the topographic map, and emerging as a very effective tool for a planning engineer for the decision making at strategic levels especially in the areas of watershed management, hazard zonation mapping and it's vulnerability assessment, infrastructural development planning etc. This work is an attempted to co-relate the output from ASTER GDEM with the flood hazard related data generated from IRS 1D PAN data. LANDSAT 7 TM data is very much useful for supervised classification of study area by creating the sample sets. Supervised classification clears the idea about how much vegetation, barren land and water body was inundated during the flood. Young's classification is most standard slope classification so far used by the civil engineer.

India in the recent years have made of significant developments in the area of disaster management. New culture of preparedness, quick response, strategic thinking and prevention is ushered. The administrative frame work is being streamlined to deal with various disaster efforts are also being made to make disaster management a community movement wherein there is greater participation of the people. However, a lot more needs to done to make disaster management a mass movement in near future. Considering all the factors above disaster management plan for Patan tahsil is prepared with due discussion of Tahsildar Patan.

It is a need to understand the long and short term implication of floods and to plan accordingly requires the analysis combined data on metrology, topography, soil characteristics, vegetation, hydrology, settlement, infrastructure, transportation, population, social economics and material recourses.

Ultimately, properly coordinated disaster management plan with the help of all new technologies and information systems can surely reduce loss of lives, property etc. to minimize and give an up hand in flourishing the economy of the country.

## ACKNOWLEDGMENT

Authors express sincere thanks to the authorities from Government College of Engineering, Karad for permitting to undertake this study. Authors also expresss sincere thanks to the officer, engineers and especially Mr. Deepak Modak, Chief Engineer Koyana Dam Project, for the kind Co-operation.

## REFERENCES

[1] Anisoara Irimescu, Vasile Craciunescu, Gheorghe Stancalie, Argentina.Nertan, "Remote Sensing and GIS Techniques for Flood Monitoring and Damage Assessment. Study Case in Romania" pp.1-9 (BALWOIS 2010 - Ohrid, Republic of Macedonia - 25, 29 May 2010).

[2] Archana Sarkar, R.D. Singh and A.K. Lohani "Living with Floodplain Rivers – Indian Scenario" pp.1-8 (National Institute of Hydrology, Roorkee-247667, India).

[3] Flood Impact Analysis using GIS "A case study for Lake Roxen and Lake Glan-Sweden" 2005-08. ) pp.32-48 (Master Thesis).

[4] G.Venkata Bapalu, Rajiv Sinha, "GIS in Flood Hazard Mapping: a case study Of Kosi River Basin, India") pp.1-3. (Map Middle East 2005)

[5] H. P. Samant, "Flooding potential zonation using conditional probabilities – A case study on Mumbai's monsoonal flooding" pp.1-4. (Map Malaysia 2006).

[6] Joy Sanyal and Xi Xi Lu, "Application of GIS in flood hazard mapping: a case study of Gangetic West Bengal, India" pp.1-2. (Map Asia 2003).

[7] Kshirsagar Pradeep Jaywantrao, "Application of RS and GIS in Disaster Management of High Relief Bank of Western Ghat". pp.1-10,132-133. 2006-07

[8] Kulapramote Prathumchai and Lal Samarakoon, "Application of Remote Sensing and GIS Techniques for Flood Vulnerability and Mitigation Planning in Munshiganj District of Bangladesh" pp.4-9 (2008).

[9] Mukesh Vyas, "Advantages of LiDAR in Flood Modelling and Important Parameters for LiDAR" pp.1-3 (Map India 2008).

[10] Mr. Falak Nawaz, Mr. Mohammad Shafique, "Data integration for flood risk analysis by using GIS/RS as tools" pp.1-4 (Map Asia 2003).

[11] Ping Chen, Soo Chin Liew, Hock Lim, "Flood detection using multitemporal Radarsat and ERS SAR data" pp.132 (ACRS 1999).

[12] R.K.Khanna, C.K.Agrawal, Pravin Kumar, "Remote Sensing And Gis Applications In Flood Management" pp.2-10 (Central Water Commission 2007)

[13] T.P. Kafle, M.K. Hazarika, K.G. Shrestha, "Integration Of Remote Sensing And Gis With Flood Simulation Model For Flood Hazard Mapping In The

International Journal of Scientific & Engineering Research Volume 4, Issue 5, May-2013
ISSN 2229-5518
Bagmati River, Nepal" pp.257-266 (November 2006, Phuket, Thailand)

[14] Yang Cunjian Zhou Chenghu Wan Qing, "Deciding the flood extent with RADARSAT SAR data and image fusion" pp.1-5 (ACRS 1999).