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IMPLEMENTATION OF REMOTE SENSING AND IT'S APPLICATION IN BAGHMATI RIVER FLOOD CONTROL

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ABSTRACT: Flood is one of the most the most re-occurring natural hazard in the state of Bihar. The major rivers responsible for flood in the state of Bihar are Kosi, Gandak, Ghagra and Bagmati, which are the tributary rivers of Ganges. The head water catchment area of Baghmati river lies in the Himalayan state of Nepal. The high rainfall in Nepal, siltation of hydraulic structures, rivers and low topography of North Bihar causes flood occurrence in these areas on regular basis. Remote sensing and GIS plays an important role in mapping, monitoring and providing spatial database for all flood related studies. The present work focuses on the use remote sensing based topography and images in GIS environment for integrated flood study of Bagmati River, which is one of the most flood prone rivers of North Bihar.

Key Words :- **Remote sensing, Baghmati topography, Sediment , Embankment**

1. 1. Introduction

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on-site observation, especially the Earth. The term "remote sensing" generally refers to the use of satellite- or aircraft-based sensor technologies to detect and classify objects on Earth, including on the surface and in the atmosphere and oceans, based on propagated signals (e.g. electromagnetic radiation). It may be split into "active" remote sensing (such as when a signal is emitted by a satellite or aircraft and its reflection by the object is detected by the sensor) and "passive" remote sensing (such as when the reflection of sunlight is detected by the sensor)

2. Study Area

The river Bagmati, one of the perennial rivers of North Bihar, originates in Shivpuri range of hills in Nepal at latitude 27o47'N and longitude 85o17'E, 16 km North-East of Kathmandu at an elevation of 1500m above MSL. The river Bagmati traverses nearly 195km in Nepal territory before it debauches into the plains. Thereafter it covers nearly 394km in Bihar before out falling in the Kosi. It receives tributaries Lakhandai, Lalbakya and Adhwara system. The river ultimately out falls in Kosi at upstream of Baltara in Khagaria district. Its total catchments area is 13,424 km2 out of which 6,320 km2 lie in India. Its total length is 589 km (India-WRIS). The catchment of the Bagmati basin located on the south of the Himalayan range in Nepal and north of river Ganges in India and lies between the Burhi-Gandak basin on the west and the Kamla-Balan basin on the east. River passes through two distinctly different terrains. From the origin to a little upstream of the Indo-Nepal border the catchment is hilly and full of forest, whereas in the downstream up to its confluence with the Kosi, the catchment is almost plain.

Bagmati originates in Himalayas which is a young mountain and made up of soft and friable sedimentary rocks. As a result, like any other Himalayan river, Bagmati carries heavy loads of sediments including silt, sand and boulders. Further, during its course in mountain it has very steep bed slope causes very high velocity and capacity to carry as much as sediments.

As soon as Bagmati enters in Terai region, it gets opportunity to spread all over and moves slowly in plain. As it flows to Bihar the river is full with silt load and is notorious for changing its course and braids into many branches one of such branch joins Burhi Gandak river near Begusarai and the combined river drains into Ganga east of Begusarai while the main channel runs east to drain into Koshi at Badlaghati

3. Baghmati Topography

In addition, its sediments carrying capacity reduces significantly and big boulders gets settle followed by sand particles. Deposition of fine silt particles occurs in later course of stream. Thus erosion in up hills and deposition in plains is a continuous process. Sediments deposited in channel offer resistance to flow. Over a time period river cuts channel and changes its course to follow a new path with least resistance. Probability of changing course depends on load of sediments. For Himalayan rivers this probability is much higher which makes flood situation worst.

In addition, after crossing Himalayas, the slope of the Bagmati reduces significantly and river flows through flat topography till it meets Kosi. In Dheng slope of Bagmati river bed is 53 cm/km (i.e. 0.053%) which decreases to 14 cm/km (i.e. 0.014%) in Hayaghat (196 km downstream from Dheng) and further it slashes to just 4 cm/km (i.e. 0.004%). At such low slope water cannot flow, it will just move. In such circumstances even a small hurdle in a flow is capable to push water in upstream by significant length. And thus it is one of the reasons that region remains waterlogged for days after flood.

In addition, sediments deposited in channel reduce Bagmati's cross section and therefore water carrying capacity. In this situation sudden rise in water flow forces the water to cross its banks and flood the surrounding region. Moreover Bagmati flows through typical topography during its course between Dheng to Hayaghat. In general as river moves, its flow increases because of additional water drained by its tributaries and increase in its catchment area. But Bagmati shows a reverse trend during flood period.

It means majority of water which was supposed to flow through Hayaghat was spread in surrounding region which has topography like a plate. Unless and until plate overflows water cannot move ahead. In this region flood water of Bagmati intrudes in its tributaries and cause flood situation in their catchments. This typical topographic feature put villages located alongside Bagmati between Dheng to Hayaghat into dangerous flood situation. Without flooding the region in between, Bagmati cannot move ahead to Hayaghat. Thus, floods are not new to this region. Since long time people have settled in this territory and have been facing flood problems but then also population density is considerably high in this region. As per the census of 2001, district Sitamandhi, Shivhar, Muzzafarpur, and Darbhanga has population density of 1169, 1165, 1179 and 1446 per sq. km respectively and it is much more than the rest of the Bihar. (If we compare the figures with Maharashtra, except Mumbai, district Thane and Pune are the most populous district of the state with population density of 850 and 462 per sq. km respectively). Then the question arises; why population density is very high irrespective of yearly flood situation?

4. 1-D hydrodynamic flood modelling

As HEC-RAS HD model could not give satisfactory results this river, the HD modelling was done using Mike-11 HD model. In the mike-11 model, time series data was provided at starting point, i.e., Dheng, river network file, cross section were given in river and cross section editor, and boundary conditions, HD model setting are given in simulation editor. For Dheng, inflow and for Benibad, water level is used as boundary type. The tim period of simulation was taken from 1st August 2002 to 30 September 2002, with 15 minutes time step. Bed resistance is taken as Manning's "n", with value of 0.05 for river bed and flood plain resistance is kept as 0.20. Based on the results of HD simulation, it is observed that we have same results for cross sections between Dheng and Runnisaidpur,

It can be explained due to extent of reach taken for simulation in two studies. We have started our simulation from Dheng itself, whereas, CWC took Karmaiya in Nepal as its starting point. Variation in cross sections and rating curve at Dheng may also be the other reason. Longitudinal water profile derived from HD simulations clearly depicts that from Dheng, 22km to 39 km reach is at maximum risk. The embankments between this reach sustain maximum water pressure and are prone to breach . After Runnisaidpur, river cross section has very less conveyance area and river flows almost through flood plains.

1D/2D hydrodynamic models in GIS environment to see the water levels, discharge and inundated flood areas in the downstream reaches. Thus, a complete flood management information system in near real time can be created based on the current and additional datasets and proper selection of hydrological/hydraulics models for Bagmati basin. The predicted flood inundation area can be verified with the Digital image processing of SAR (RADARSAT, RISAT, ENVISAT and TerraSAR) images during actual flood events.

5. Sediment

During flood water of Bagmati spreads all around the valley. It deposits silts in fields. In addition flood water maintains ground water level. The silt is highly nutritious and maintains fertility of soil. The valley produces good yield without a pinch of any fertilizers. The region has plenty of water and never faces drought situation. Author reports that this is the one of the regions of our country where we do not get to see woman fetching water from distant sources. Because of availability of water and fertile soil the region is preferred by mankind for settlement since ages. Even today we come across old farmers in this region reporting that in kharif and rabi season they used to go to farm only for harvesting crop after broadcasting seeds. People faces problems during flood but enjoy bumper crop afterwards. If the flood was the major problem of the region, people would have runaway long back. But they have not!

6. Construction of embankments

The easiest way one can think to tackle flood situation is a construction of embankment along the channel. It protects alongside villages by establishing a safe zone. And that is what we are doing since last 50 years under various irrigation and flood control schemes. Total length of Bagmati river is 394 km in Bihar. Till today embankment of around 450 km has been constructed or under construction on both the banks of Bagmati. Still after spending thousands of crores, construction of embankment is a controversial issue. Evan engineers do not have consistent opinions about its utility.

As per the rationale put forward by engineers, after construction of embankment river is forced to flow between embankments. It reduces its cross-section and increases velocity of stream. Increased velocity further enhances erosion capacity of river which in turn erodes the banks and substrate, and increases cross-section of stream. Increased cross-section means more flow which helps in receding flood water faster and saves the surrounding region. But in reality velocity does not increase and thus erosion capacity. Because of embankment water cannot move anywhere and deposits all sediments in channel, thus river substrate moves up which subsequently escalate flood line.

Afterwards it becomes necessary to strengthen the embankment and increase its height to avoid flood. In subsequent years of construction, river substrate moves up due to continuous deposition. But strengthening and heightening of embankment has got its own limitation. And somewhere during flood water overflows causing breaches in embankment. Sometimes embankment cracks because of water pressure. Often it is observed that animals like rats, fox make holes in embankment which gets filled by flood water and forms crack in embankment because of pressure. Breaches in embankment put surrounding villages in disastrous situation.

7. Conclusion and recommendation

Embankment has got its own problems. After construction of embankment water from local subsidiary streams cannot enter in main stream. Then either it flows in backward direction or moves parallel to main stream but outside the embankment i.e. through safe zone. In both the situation it submerges surrounding villages. Then option left in hand is to construct a sluice gate where a subsidiary stream meets main stream. But the problem with sluice gate is that it does not function after its construction.

During rainy season it gets jammed because of heavy sediment deposition at the bottom of both sides of the gate. Moreover, during heavy rainfall it is dangerous to open sluice gate because if the water level in main stream is more than the subsidiary stream then water will flow in reverse direction and will flood the safe zone on countryside. Therefore sluice gate functions only after rainy season when water level in main stream is much lower than the subsidiary stream.

Flood is one of the most the most re-occurring natural hazard in the state of Bihar, as well as in India. The major rivers responsible for flood in the state of Bihar are Kosi, Gandak, Ghagra and Bagmati, which are the tributary rivers of Ganges. The head water catchment area of these rivers lies in the Himalayan state of Nepal. The high rainfall in Nepal, siltation of hydraulic structures, rivers and low topography of North Bihar causes flood occurrence in these areas on regular basis. Remote sensing and GIS plays an important role in mapping, monitoring and providing spatial database for all flood related studies. The present work focuses on the use remote sensing based topography and images in GIS environment for integrated flood study of Bagmati River, which is one of the most flood prone rivers of North Bihar. The Digital Elevation Model (DEM) from shuttle radar topography mission (SRTM) was used to create detailed sub-basin and river network map of entire Bagmati basin. The floods of July–August 2002 were mapped using RADARSAT-1 data using threshold based method. The SRTM DEM and ground based river cross-section from Dheng to Benibad stretch of Bhagmati River were used to create 1-dimensional hydrodynamic (1-D HD) model for simulating flood water level, discharge and flood inundation. Validation of simulated flood flows was done using observed water level of central water commission (CWC) from Dheng to Runisaidpur stations, with coefficient of correlation of 0.85. Finally, an integrated framework for flood modelling and management system is proposed.

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