# FLOODPLAIN ANALYSIS AND RISK ASSESSMENT OF LOTHAR KHOLA (STREAM)

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## Abstract:

This study aims to find out the extent of floodplain for flood discharge of different return periods using one dimensional hydraulic model HEC-RAS, ArcView GIS and Hec-GeoRAS to inference between HEC-RAS and ArcView GIS in Lothar Khola with catchment area of 170 km², lying between Chitwan and Makawanpur Districts, Nepal. Triangulated Irregular Network (TIN) was prepared from contour and spot elevations in ArcView GIS; required data sets were prepared in HEC-GeoRAS and import file was created and imported in HEC-RAS. In HEC-RAS, boundary conditions, flood discharges for different return periods were inputted. Steady flow analysis and flood risk assessment were carried out. Area inundated by 2, 10, 50, 100 and 200 years return period flood was 230, 239, 246, 249 and 252 ha., respectively. The classification of flood depth area shows most of the flooding area has water depth greater than 3m. The large percentage (> 40 %) of vulnerable area lies on sand area followed by forest, cultivation area, etc. Also, flood area increases with flood intensity. Higher flood depth increases and lower flood depth decreases with increase of flood intensity. Flooding of cultivation land indicates potential damage in food production and negative effects on the livelihoods of local people. Thus, the study may help in planning and management of watershed area for mitigating future probable disaster through technical approach.

**Keywords:** Flood, Arc GIS, Arc View, HEC-RAS, Lothar Khola,

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1. Introduction

Nepal, occupying the central part of the Hindu-Kush Himalayan belt, about 83 per cent of its land area covered with mountainous terrain and the remaining 17 percent in the south lies in the alluvial plains. High relief, steep slopes, complex geological structures with active tectonic processes and continued seismic activities, and a climate characterized by great seasonality in rainfall, all combine to make her natural disasters prone area, especially water-induced disasters.

According to Dilley et al. (2005), Nepal falls in 11th position on disaster vulnerability in the world and half of its population is under the threat of four types of disaster at a time including flood. The problem of flood in certain plain areas in Nepal is a chronic problem and cause tremendous losses in terms of property and life. The majority of flood disasters’ victims are poor people living in flood plain. In Nepal, between 1983 and 2008, flood and landslides caused 57.89% of the total loss of properties from different types of disasters. On an average yearly, 290 people lost their lives accounting to over 33.8% of those who died due to different types of disasters (DWIDP, 2008).

The floods of 1993 and 2002 have caused severe inundation in the study area of Lothar Khola watershed. In 1993, damaged land and houses in various VDCs. About 1000 ha of paddy land inundated, 17 households shifted for three months, killed two people and a large numbers of cattle in this area. In 2000, paddy crops were damaged along the river banks of the Lothar Khola and around 20-50 HHs inundated in all the affected VDCs. In 2002, approximately 20 houses, one primary school, 32 bigas of paddy land were completely damaged and two people and large number of cattle were killed. Approximately one km of blacktop road of East West highway was washed away. In 2007, losses of three lives in Chitwan in monsoon, among them two persons were dead of floods, drowned by Lothar Khola (Disaster Watch - Nepal, 2007).

This particular vulnerability of local people underlines the urgent need to promote relatively fast and socially accepted cost effective structural as well as non-structural counter-measures that should be planned and implemented by community according to their real needs and affordability. Thus, this paper focuses on floodplain analysis and risk assessment using one dimensional hydraulic model HEC-RAS, ArcView GIS and Hec-GeoRAS to inference between HEC-RAS and ArcView in the areas susceptible to living, agricultural practices, etc in floodplain of Lothar Khola (stream).

2. Materials and methods

2.1 Study area

Lothar Khola with a catchment area of 170 sq. km., lies between Chitwan and Makawanpur District, with mean monthly dry season discharge (May) is 2.05 m³/sec and average discharge during monsoon (June-September) is 10.17 m³/sec (DHM, 2006). The average annual rainfall in the area is 1944 mm and the maximum rainfall of 24 hrs is 130.17 mm. It extends between 27° 33’ N to 27° 35’ N Latitude and 84° 41’ E to 84° 50’ E longitude (Fig. 1). The elevation of the watershed ranges from 2080 m to 220 m.
2.2 Methods
The general method adopted for floodplain analysis and flood risk assessment in this study basically consists of five steps: (1) Preparation of TIN in ArcView GIS, (2) GeoRAS Pre-processing to generate HEC-RAS Import file, (3) Running of HEC-RAS to calculate water surface profiles, (4) Post-processing of HEC-RAS results and (5) Floodplain mapping and Flood risk assessment. The approach used for floodplain analysis and risk assessment using one-dimensional model using HEC-RAS, GIS and HEC-GeoRAS is shown in Fig. 2.

The major data for the model development consisted of the topography and river channel and hydrologic data for the floods of different return periods. For the preparation of TIN in ArcView Digital contour data at interval 20m is used and land use/landcover map is derived from the 1992 topo-sheet along with field verification.

The methodology adopted for flood risk assessment follows the approach developed by Gilard (1996). The flood risk analysis includes the combination of the results of both the vulnerability assessment and the hazard assessment. This is defined by the relationship between the land use vulnerability classes and the flood depth hazard classes in a particular area. For this, the flood risk maps are prepared by overlaying the flood depth grids with the land use map of different year return period flood. The flood depth polygons prepared during the hazard analysis are intersected with the land use vulnerability polygons. The resulting attribute tables are reclassified to develop the land use-flood depth relationship. The vulnerability assessment is facilitated by the use of the binary model, based on the presence or absence of a flood of particular intensity in a particular land use type.
The vulnerability maps for the flood areas were prepared by intersecting the land use map of the floodplains with the flood area polygon for each of the flood event being modeled. The spatial coexistence model is used for the hazard assessment, reclassifying the floodwater depth. The results of these two analyses are combined for the flood risk assessment.
3. Findings

3.1 Flood Frequency Analysis
The result of 2, 10, 50, 100 and 200 years Return Period Flood Frequency Analysis based on Maximum Instantaneous flow recorded at Lothar khola (Station 470) from year 1964 – 2004 using Gumbel’s, Log Pearson Type III (LP III) and the Log Normal (LN) are summarized below in Table 1 respectively.

It is observed that flood frequency analysis by Log Pearson Type III showed discharges of 286, 647, 990, 1137 and 1284 m³/sec. for 2-years, 10-years, 50-years, 100-years and 200-years respectively, which were slightly high as compared to the results obtained by Gumbel’s, Log Normal method, which were used for modeling.

<table>
<thead>
<tr>
<th>Station 470, Lothar Khola</th>
<th>Return Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Gumbel (m³/s)</td>
<td>305</td>
</tr>
<tr>
<td>LN (m³/s)</td>
<td>339</td>
</tr>
<tr>
<td>LPIII (m³/s)</td>
<td>286</td>
</tr>
</tbody>
</table>

3.2 Steady Flow Analysis
It is observed that the flood inundation areas were 230, 240, 247, 250 and 253 ha for 2-year, 10-year, 50-year, 100-year and 200-year return periods respectively, which showed moderate increase after 50-year return period (Fig. 3).

Steady Flow Analysis performed in HEC-RAS showed discharges of 286, 647, 990, 1137 and 1284 m³/sec inundated 230, 240, 246, 249 and 252 ha area respectively. Area inundated with respect to discharge showed that there was just slight increase in inundated area (Fig. 4).
3.2 Flood Hazard Analysis

The hazard aspect of the flooding is related to the hydraulic and the hydrological parameters. The results of this assessment are summarized in Table 2. The classification of flood depth areas indicated that 52 to 84 % of the total flooded areas had water depths greater than 3 m. The total area under the water depth of 1-1.5 m was quite small. Flood hazard maps of the study areas for 2-year, 10-year, 50-years, 100-year and 200-year return periods was prepared by overlaying flood grid depths with the TIN.

Table 2: Calculation of Flood Area according to Flood Hazard

<table>
<thead>
<tr>
<th>Water Depth (m)</th>
<th>2 Year Flood</th>
<th>10 Year Flood</th>
<th>50 Year Flood</th>
<th>100 Year Flood</th>
<th>200 Year Flood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area</td>
<td>%</td>
<td>Area</td>
<td>%</td>
<td>Area</td>
</tr>
<tr>
<td>1 - 1.5</td>
<td>10.59</td>
<td>4.62</td>
<td>8.70</td>
<td>3.63</td>
<td>5.80</td>
</tr>
<tr>
<td>1.5 - 2</td>
<td>12.04</td>
<td>5.25</td>
<td>7.94</td>
<td>3.31</td>
<td>7.69</td>
</tr>
<tr>
<td>2 - 2.5</td>
<td>28.04</td>
<td>12.22</td>
<td>6.74</td>
<td>2.81</td>
<td>6.59</td>
</tr>
<tr>
<td>2.5 - 3</td>
<td>39.40</td>
<td>17.17</td>
<td>15.21</td>
<td>6.35</td>
<td>8.71</td>
</tr>
<tr>
<td>&gt; 3</td>
<td>120.42</td>
<td>52.49</td>
<td>186.03</td>
<td>77.72</td>
<td>205.75</td>
</tr>
<tr>
<td>Total</td>
<td>229.41</td>
<td>100.00</td>
<td>239.37</td>
<td>100.00</td>
<td>246.75</td>
</tr>
</tbody>
</table>

For 2-year flood, it is observed that, inundated area with water depth >3, 2.5-3, 2-2.5, 1.5-2, 1-1.5, <1 meter were 120(53%), 39(17%), 28(12%), 12(5%), 10(4%), 19(8%) ha respectively (Fig.5 (A) & (B)) and for 200-year flood were 213, 7, 6, 8, 8, 11ha respectively, which showed flood water depth >3 increased with increase in the intensity of flooding and flood water depth <1 decreased with the increase in the intensity of flooding.
3.3 Flood Vulnerability Analysis

This depicts the vulnerability aspect of the flood risk in the particular area in terms of the presence or the absence of flooding of a particular return period as a binary model. The assessment of the flood areas indicated that a large percentage (more than 40%) of vulnerable area lied in flood plain area i.e. sand area followed by forest and cultivation area comprising 23% and 18% respectively.

<table>
<thead>
<tr>
<th>Land use type (ha)</th>
<th>Total Vulnerable Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 year flood</td>
</tr>
<tr>
<td></td>
<td>Area</td>
</tr>
<tr>
<td>Barren Land</td>
<td>0.01</td>
</tr>
<tr>
<td>Cultivation</td>
<td>41.93</td>
</tr>
<tr>
<td>Cutting Area</td>
<td>0.04</td>
</tr>
<tr>
<td>Forest</td>
<td>52.43</td>
</tr>
<tr>
<td>Orchard</td>
<td>0.01</td>
</tr>
<tr>
<td>River</td>
<td>26.08</td>
</tr>
<tr>
<td>Sand Area</td>
<td>108.93</td>
</tr>
<tr>
<td>Total</td>
<td>229.42</td>
</tr>
</tbody>
</table>

The Table 3 and Fig 6 showed that 42, 53, 26, 108 ha of cultivation area, forest, river and sand area are respectively inundated by 2-year flood. Similarly, table showed 50, 62, 27, 114 ha of cultivation area, forest, river and sand area are respectively inundated by 200-year flood, which showed flooded area increased with increase in flooding intensity, mostly sand area was inundated by different year floods, which was followed by forest and cultivation area.
3.4 Flood Risk Analysis
This study depicts flood risks by combining land use vulnerability and the magnitude and extent of flood hazard. It is observed that for 2-year flood, water depth wise inundated areas were as follows; for cultivation area with water depth of >3, 2.5-3, 2-2.5, 1.5-2, 1-1.5, >1 meter were 12.37, 9.28, 7.64, 3.56, 4.45, 4.63 ha, for forest area were 34.69, 4.69, 4.76, 3.21, 1.49, 3.60 ha, for River were 18.13, 3.14, 1.74, 1.12, 1.05, 0.90 ha and for Sand area were 55.11, 22.29, 13.99, 4.15, 3.61, 9.78 ha respectively (Fig. 7). The assessment of flood area indicated areas under forest and cultivated land which had the flood water depth of more than 3.0 m was very high. This indicated potential damages in food production and negative effects on the livelihoods.
Conclusion

Risk assessment identified the flood prone areas, also the vulnerability in terms of the type of land use affected and hazard related to the return period of flooding and flood water depths. According to the model results, there is considerable flooding in the area even at flood discharge of 2-year flood. This implies that the channel capacity is small to carry the flood water discharge. The flood risk maps prepared indicate a high risk to the sand area, forest and cultivated land with water depth greater than three meter of the study area. These areas are the most flood prone areas in the river floodplains and need further considerations for flood protection.

The applications of hydraulic model and GIS for floodplain analysis and risk mapping have been limited in countries like Nepal, where the availability of the river geometric, topographic, hydrological data and GIS software are also very limited. The situation of river flooding in Nepal is also completely different, as there is much higher variation in the river flows and rivers are completely unregulated. There are very few flood control structures like spurs and dikes and the river banks and boundary lines are not clearly defined. Hence, the floodplain analysis and modeling using GIS software are subject to number of new sets of constraints.

References: