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ORIGINAL ARTICLE

Effect Of Flood On Land Use In Different Return Periods: A Case Study From The Lower Haora Basin, Tripura, North-east India

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Abstract:

Floods are natural phenomena that occur when water from rainfall, snow melt, dam failure or any combination of these is released into a stream at rates that exceeds the transfer and storage capacity of the channel. Flooding is responsible for both annual loss of life and property damage.

The River Haora is the Life Line of Agartala Municipal Area. It is the smallest river among the ten major rivers of Tripura with a length of 53 km only. It originates from the Baramura Hill Range (947m) and flows westward, passes through Agartala, the capital city of Tripura, enters into Bangladesh and meets the River Titas.

The River Haora suffers from occasional flood during heavy monsoon shower which damage the standing crops in the fields and the flood water enter into the houses and water logged condition prevails for longer time. In order to study the flood plain land use, flood frequency analysis has been done using Weibul's method of flood frequency. Relation between average annual discharge and gauge height, annual peak discharge and Return Period, probability of flood etc have been calculated and plotted on log log/semi log graph paper. Then through the method of extrapolation the 10, 50 and 100 years return periods and related discharge and gauge height have been calculated. Then on the basis of these hydrological and topographic criteria flood hazard maps have been prepared for these return periods. Accordingly land use map of those hazard zones have been prepared. The study also covers the extent of agricultural and residential areas affected by the flood in Pratapgarh mouza. At last some suggestions have been placed to mitigate the losses during flood in the study area.

KEYWORDS:

Flood, Land use, Flood frequency analysis, Return period, Flood hazard, zone.

INTRODUCTION:

Floods are natural phenomena that occur when water from rainfall, snow melt, dam failure or any combination of these is released into a stream at rates that exceeds the transfer and storage capacity of the channel. Flooding is responsible for both annual loss of life and property damage. Identification of flood affected areas is an important input for taking up flood management schemes for alleviating the problems of

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the people affected by floods. The basic principle involved in all the methods concerned with mitigation of floods is to "keep floodwaters away from the man and man away from the floodwater" (Dhar and Nandargi,2004). In today's world, even remote corners of river basins have been occupied, forest cover has been destroyed and hilltops have been cultivated (jhum cultivation) to produce more food to feed the teeming millions. In recent decades flood has increased both in volume and frequency. This has resulted in increased erosion of hill slopes and river banks. As a consequence, the river beds have silted up, decreasing the carrying capacity of rivers and the rivers tend to change their courses. The River Haora experiences such hazards among which floods are frequent.

OBJECTIVE:

In order to carry out in-depth studies of floodplain land use of Pratapgarh Mouza, following objectives have been selected:

1 To analyze the flood frequency.
2. To prepare land use map of the Pratapgarh Mouza.
3. To prepare flood hazard map for different return period.
4. To assess the affected areas for 2, 10, 50 and 100 year return periods of flood.

METHODOLOGY:

In order to prepare this paper intensive field work has been carried out in the study area. For flood frequency analysis 28 years discharge and gauge height data have been taken into consideration. By the method of extrapolation the expected discharge and gauge height have been calculated for 50 and 100 years'. On the basis of the gauge height four flood hazard maps have been prepared. The land use map of the study area has also been prepared to calculate the affected areas under agriculture, settlement etc for different return periods of flood so that the proper land use planning can be done.

In order to carry out this micro level study on land use of Pratapgarh Mouza, located within the floodplain of the River Haora, main constraint faced by the authors are the non-availability of hydrological data for longer period which is essential for any research work on flood. Only 28 years' discharge data is not sufficient for calculating higher return periods of flood through extrapolation method. Therefore this study is an experiment for approximate calculation of flood return period for the Pratapgarh area located in the lower Haora basin.

FLOOD FREQUENCY ANALYSIS:

Flood Frequency Analysis is the determination of flood flows at different recurrence intervals/return periods. The standard procedure to determine probabilities of flood risk consists of fitting the observed stream flow record to specific probability distributions. However this procedure only works for basins that have long enough stream flow records to warrant statistical analysis; where flood flows are not appreciably altered by reservoir regulation, channel improvements (levees) or land use change (Aggarwal, 2008). The objective of flood frequency analysis is to relate the magnitude of extreme events to their frequency of occurrence using probability distributions. The frequency or probability of a flood usually is described by assigning a recurrence interval/return period to the flood at each gauging station. This is accomplished by statistically evaluating long term annual peak stream flows at a station. e.g. a 100 year flood recurrence interval means that in any given year, a flood of a specified stream flow magnitude has a 1 in 100 chance of happening.

The hydrologic data for flood frequency analysis should be carefully selected so that assumptions of independence and identical distributions are satisfied (Chow, et al. 1988). In practice, this is often achieved by selecting the annual maximum of the variable being analysed e.g. the annual maximum discharge, which is the largest instantaneous peak flow occurring at any time during the year. In order to calculate flood frequency, 10 years peak discharge of the River Haora at Pratapgarh was available.

The return period or recurrence interval (T) is the average interval of time within which a discharge of a given magnitude will be equaled or exceeded at least once. It is the time scale used for flood frequency curves and is plotted along the abscissa. Generally there are two commonly used methods for manipulating discharge data in flood frequency studies. The first method is the annual flood array in which only the highest instantaneous peak discharge in a year is recorded. The list of yearly peak flows for the entire period of record are then arranged in order of descending magnitude, forming an array. The recurrence interval of any given flow event for the period of record can be determined by using Weibul's

formula (1939) and is calculated by using the formula:
T = (n + 1)/m
Where, n = number of events i.e., years of record.
m = order or rank of the event (flood item)
T= recurrence interval

Some hydrologists and geomorphologists object to the use of annual floods because this method uses only one flood in each year and occasionally, the second highest flood in a given year (which is omitted) may outrank many annual floods.

The other method commonly used in flood frequency analysis is the partial-duration series. When using this method, all floods that are of greater magnitude than a pre-selected base, are listed in an array without regard to whether they occur within the same year. This method also draws criticism in that a flood listed may not be truly an independent event; i.e. flood peaks counted as separate events may in fact represent one period of flooding.

The simplicity and general reliability of the annual flood array method is appealing and the researchers have used this method. For the present study 10 years discharge data have been taken for calculating the return period and to calculate percent probability. A flood recurrence interval /return period of 29 years means that, in any given year, a flood of 394.88cumec peak discharge or more has a 1 in 29 chance of happening. The exceedence probability and the return period are reciprocals to each other.

Table 1: Return Period and chance Probability of Flood in Pratapgarh (Annual Flood Array Method according to Weibul)

Discharge (cumec) in descending order	Rank (m)	Return period T= (n+1)/m	Exceedence Probability P(x) = 1/T	Per cent Probability P=1/T×100
394.88	1	29	0.03	3.45
319.70	2	14.5	0.07	6.90
246.90	3	9.67	0.1	10.34
233.50	4	7.25	0.14	13.79
226.22	5	5.8	0.17	17.24
208.90	6	4.83	0.21	20.70
204.30	7	4.14	0.24	24.15
188.00	8	3.63	0.28	27.55
185.40	9	3.22	0.31	31.06
160.63	10	2.9	0.34	34.48
159.33	11	2.64	0.38	37.88
158.30	12	2.42	0.41	41.32
153.90	13	2.23	0.45	44.84
152.12	14	2.07	0.48	48.31
148.17	15	1.93	0.52	51.81
145.00	16	1.81	0.55	55.25
140.67	17	1.71	0.58	58.48
138.67	18	1.61	0.62	62.11
138.01	19	1.53	0.65	65.36
127.49	20	1.45	0.69	68.97
121.80	21	1.38	0.72	72.46
119.00	22	1.32	0.76	75.76
116.49	23	1.26	0.79	79.37
112.00	24	1.21	0.83	82.64
107.24	25	1.16	0.86	86.21
98.00	26	1.12	0.89	89.29
78.04	27	1.07	0.93	93.46
73.31	28	1.04	0.96	96.15

Source: Calculated by the researcher on the basis of the discharge data provided by the Central Water Commission (restricted data).

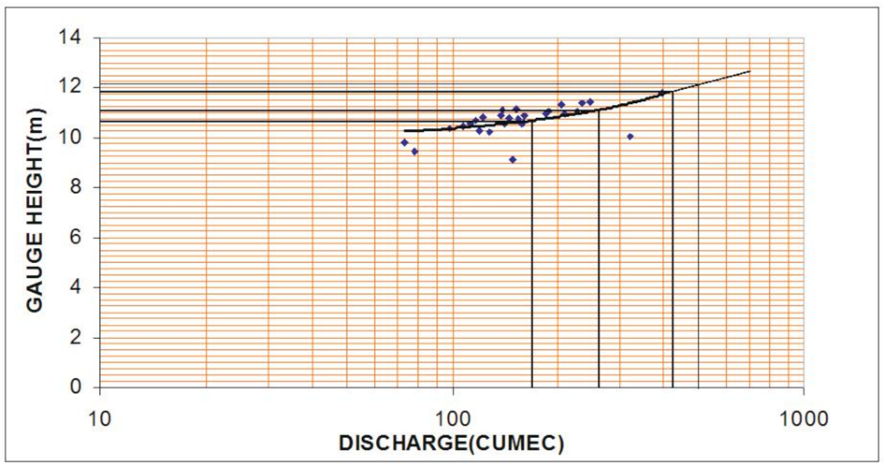
Then Rating Curve (Fig. 1) has been drawn showing annual peak discharge along the abscissa and gauge height along the ordinate. In order to calculate correlation among these two variables Pearson's Method of Correlation Coefficient has been followed.

Table 2: Pearson's Correlation between discharge and gauge height

		Discharge	Gauge Height
Discharge	Pearson Correlation	1	.540**
	Sig. (2-tailed)		.003
	N	28	28

** Correlation is significant at the 0.01 level (2-tailed)

The correlation between discharge and gauge height of the River Haora is significant (0.54) which means that the association between these two variables is very strong and positive value indicates also that if there is an increase in discharge, the gauge height will also increase or vice versa.



Flood recurrence and associated discharges have been plotted on log-log graph along the abscissa and ordinate respectively to draw the Flood Frequency Curve (Fig. 2). Then have graphically extrapolated the frequency curve along the upper trend so as to include 100 year flood event. From the graph discharges expected for the 2, 10, 50 and 100 year floods have been determined.

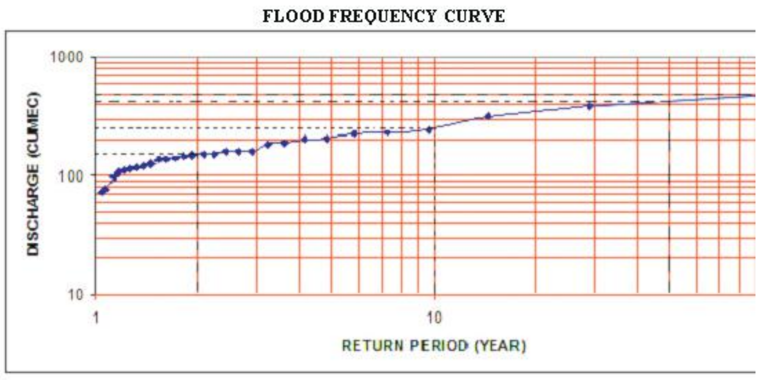


Fig. 2: Flood Frequency Curve with discharge of 2, 10, 50 and 100 years recurrence interval /return period.

Again by extrapolating the Rating Curve along the upper trend the gauge heights associated with each of these discharges of different return periods have been determined.

Table 3: Discharge and Gauge Height associated with different Return Periods

Return period	Discharge (cumec)	Gauge height (m)
2	165	10.65
10	260	11.15
50	420	11.80
100	500	12.20

Source: Calculated by the researcher from Fig. 1 and 2.

The estimation of parameters and the selection of the distribution become unreliable when the observed data happens to be very small. In such cases, the probabilities can be obtained from the frequency analysis without bothering about which distribution the random variable follows (Reddy, 2006). A graph (Fig. 3) is prepared between the annual peak discharge (Table1 Column 1) as the abscissa and the corresponding exceedence probability (Table 1 Column 4) as the ordinate. From this figure annual peak discharge corresponding to the exceedence probabilities of 100%, 75%, 50% and 25% are read as 86.50, 110, 145 and 205 cumec respectively. That means at Pratapgarh we can expect a peak discharge of 205 cumec or more in 25 years out of 100 years and so on. From the same figure the exceedence probability for any discharge may also be read.

EXCEEDENCE PROBABILITY OF DISCHARGE

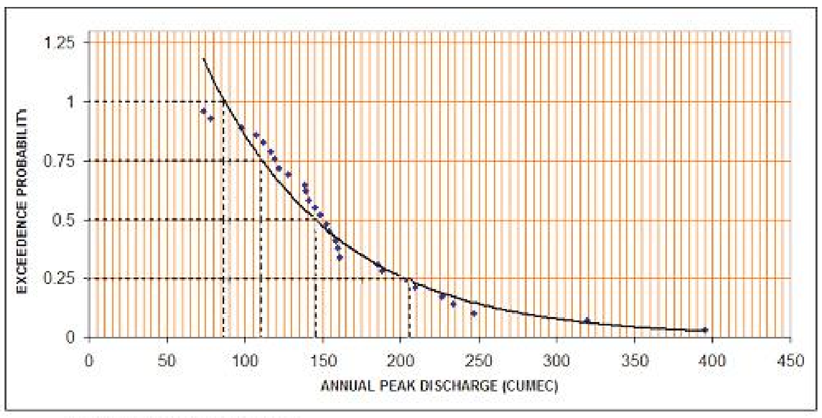


Fig. 3: Probability plot.

LAND USE MAP OF THE PRATAPGARH MOUZA:

Normally it has been said that the residential area should be constructed far away from the river. But the land use map of Pratapgarh reveals that predominantly residential areas are situated nearer to the river bank. The map also shows that there is lack of land use planning. People construct their mud houses there because the land is cheap; ultimately they are the worst affected from flood.

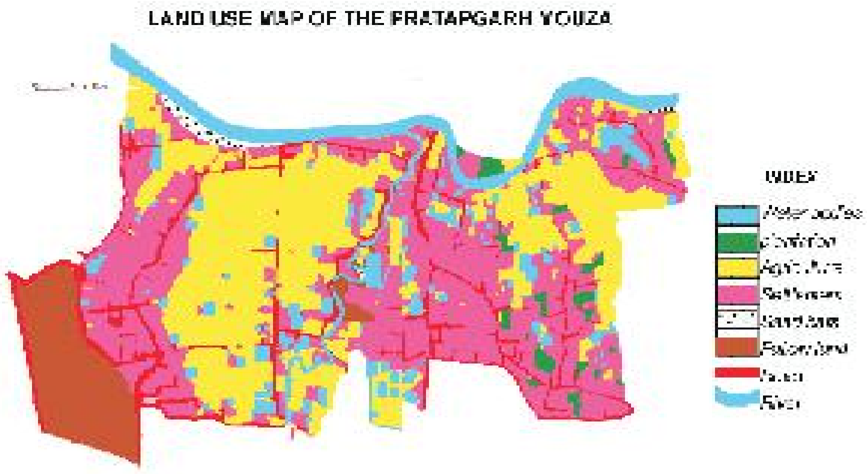


Fig 4: Land Use Map of the Pratapgarh Mouza, a part of the lower Haora Floodplain.

FLOOD HAZARD MAP:

Flood hazard mapping is a basic tool for flood preparedness and mitigation activities, including flood insurance programme. In order to prepare the flood hazard zones a long term data is essential which is lacking in Tripura. Therefore the whole study is experimental and has been done on the basis of 28 years discharge data. In order to mark the flood inundated areas during return periods of 2, 10, 50 and 100 years the researcher considered both hydrological criteria and topography. Moreover she has to depend on the primary data collected from the local people and from the water mark on the houses and wooden bridges after flood. Accordingly she has calculated the possible areas of inundation away from the River Haora on the cadastral maps of Pratapgarh considering the topography of the area and other man-made structures. This is an attempt to prepare a micro-level flood hazard zonation map which could be beneficial for identifying the risk zone of flood. So the people will reside in those areas at their own risk by knowing about their fate during flood. Areas inundated during 2 years return period fall under this risk zone.

Land Use Area Inundated in Different Flood Return Periods

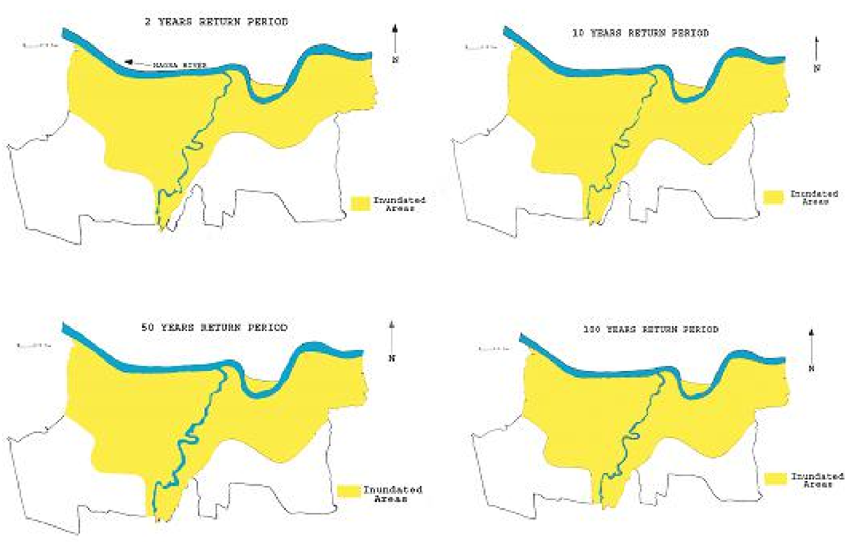


Fig. 5: Land Use areas inundated during 2, 10, 50 and 100 years Return period of flood.

Table 4: Return period-wise inundated areas under different land use

(Areas in acre)

Return period	Cultivated land (%)	Settlement (%)	Water body (%)	Road (%)	Plantation (%)	Fallow land (%)	Sandbar (%)	Total area inundated (%)
2 yr	86.36 (48.41)	52.39 (29.37)	29.83 (16.72)	6.87 (3.85)	1.61 (0.90)	0.91 (0.51)	1.33 (0.75)	178.39 (100)
10 yr	94.41 (32.35)	57.58 (19.73)	30.99 (10.62)	7.36 (2.52)	1.73 (0.59)	1.04 (0.36)	-	291.81 (100)
50 yr	97.31(32.42)	59.87 (19.95)	31.09 (10.36)	7.66 (2.55)	1.75 (0.58)	1.06 (0.35)	-	300.17 (100)
100 yr	100.18 (32.61)	61.60 (20.05)	31.16 (10.14)	7.83 (2.55)	1.80 (0.59)	1.11 (0.36)	-	307.18 (100)

Source: Calculated by the researcher.

By superimposing the return period- wise flood inundation map on the land use map of the Pratapgarh Mouza, the affected areas have been calculated for the mentioned return periods. It is clear from Table 4 that approximately for all the return periods mostly agricultural lands and built up areas will be affected. In 2, 10, 50 and 100 years return period of flood about 78%, 52.1%, 52.37% and 52.66% respectively are agricultural and settled areas. Therefore proper floodplain land use planning is required to minimize losses and measures to protect the area from frequent flooding.

SUGGESTIONS TO MITIGATE THE LOSSES:

· Flood hazard is destructive and frequently occurring phenomenon in the study area. Due to the lack of proper warning system, information about the occurrence of flood is not communicated effectively to the people living in the flood prone areas. There is a lack of land use planning in the study area. Lack of official record of hydrological data is also a problem for preparing hazard map. Flood risk zones should be demarcated for effective flood plain land use planning.

· It appears that excess and haphazard development and rapid population growth in the valley and floodplain have primarily resulted in increased vulnerability of population to flood hazard. As more and more people populate flood-prone areas, the potential for damage from flood increases. Hence, it is necessary to take concrete measures to stop further population growth in the flood plain areas and the present population settled in flood plain area (mainly slum population) should be moved in another place.

· In the upper catchment areas jhum cultivation causes soil erosion. Therefore deforestation activity should be stopped.

· Government should take a programme for increasing the depth of the River Haora and its tributaries through dredging.

· During the collection of secondary data it has been observed that during flood the discharge data is unavailable which is very essential. For the proper management of the flood the regular record of hydrological data should be maintained.

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