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Flood hazard and damage assessment in former Jalpaiguri district of West Bengal, India

Moitrayee Das[1]*, Anis Chattopadhayay[2] and Ranjan Basu[3]

[1]Assistant Professor, Post Graduate Department of Geography, Chandernagore College, West Bengal, India; [2]Retd. Professor, Department of Geography, Presidency College, West Bengal, India; [3]Professor, Department of Geography, University of Calcutta, West Bengal, India.

***Corresponding author:** moitre_alap@rediffmail.com

Abstract

Flood is the most common and natural phenomena of any flood prone region and damage is also very common event related to flood hazard of any magnitude. Impact of flood in any particular area is always concerned with the damage created by the flood. Flood (Damage) Impact Assessment (FIA) is a technique to assess flood impact in flood prone regions. It helps to quantify and understand the extent of a given society will compromise with damage and the extent of the said society accepts the flood event as or a hazard, such that flood can be viewed either as flood threshold limit or as flood hazard. The threshold limits to predict or indicates how far the society will take flood as an event with its corresponding damages. Jalpaiguri is a district of West Bengal, which has faced flood almost every year. This flood causes damage over the district. However, the intensities of damage vary from year to year. Analysis of the actual amount of ex-post damage calculation of human effect, property and environment loss is too hard**.** Present papers have been analysed flood damage of the district or the flood impact assessment and assess the original hazardous condition of the district in past 43 years. It's also expressed in high flood situation (1998) the block-wise damage impact assessment of flood.

Keywords: Flood damage, flood hazard, flood impact, threshold limit.

Introduction

The terms 'flood damage', 'flood impact', 'flood consequences' and 'flood loss' are used regularly in the technical literature. The terms 'flood consequences' and 'flood impacts' are synonymous, and both refer to the broad effects that flooding can have on people, to property and to the environment. These consequences or impacts can be both positive and negative, although it is common in the literature to see the terms used in a purely negative sense, especially in relation to human health, where health impact assessments are conducted (Fewtrell et al., 2008). The terms 'loss' and 'damage' are also used synonymously in the literature. Damage is the negative result of the spatial and temporal impact of an event on societal elements (people, buildings, etc.), societal processes (interruption of production, services etc.) and the environment (Verger et al., 2003).

Flood damage refers to all varieties of harm caused by flooding. It encompasses a wide range of harmful effects on human their health and their belongings on public infrastructure, cultural heritage, ecological system, industrial production and the competitive strength of affected economy.

In the district of Jalpaiguri, West Bengal, flood is the most recurring and hazardous natural event. About 2000 sq.km area of land is prone to flooding which indicate 32% of the land area in the district. The bulk of population is concentrate in that particular area. Flood effect a large number of people and livelihood almost every year with unfailing regularity but the damage affect by the phenomena vary considerably from year to year. Almost all the administrative blocks of the district is more or less affected by the flood.

The temporal variation of flood hazard means year to year variation of damage by flood and the spatial variation mean areal extent of flood damage over the district. Moreover, spatial extent means administrative block wise distribution of flood damage over the district. Identification of temporal and spatial variation of the flood ex- post damage is very tuff job for the administration as well as the planner. As flood impact assessment is so critical to the practice of flood risk management, any estimates of damage should be as reliable and as accurate as possible. However, there is no common methodology that is applied to estimate flood damage internationally. There is also a difficulty in obtaining reliable historical flood damage estimates on which to base research into flood damage estimation. Ex-post estimation of damages in the district is calculated from Calamity Assessment (CA-II) report from Disaster Management Section, Jalpaiguri, (1998-2012); NBFCC (North Bengal Flood Control Commission-1970-1997); and Central Water Commission (CWC-1970-1997). In this estimation parameters have been chosen on tangible and direct flood loss with reference to which over all damage calculation has been done. These parameters are viz flood affected areas , flood affected size of population, cropped area affected by flood, value of damage to crops, number of houses partially and fully damaged, number of cattle loss, human lives loss and total loss in monetary term. Damages caused by the flood in the study area in Jalpaiguri district from 1970-2012 can be explained with these parameters.

Study area

Erstwhile Jalpaiguri district is one of the district of West Bengal, India**.** The district is geographically situated from $26^0$16'35'' North to $26^0$59'30'' North and from $88^0$04'59''East to $89^0$55'20'' East comprising

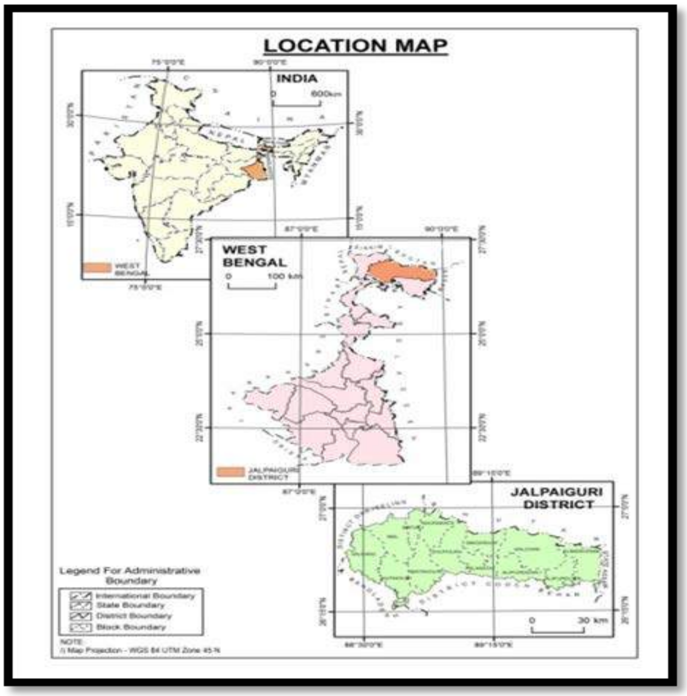

Fig. 1. Location Map

an area of 6227 sq.km [Jalpaiguri'-District Gazetteer]. In West Bengal Jalpaiguri district occupies the southern flanks of the foothills of the Himalaya. Jalpaiguri district is bounded on the north by Darjeeling district of West Bengal and Bhutan, on south by Uttar Dinajpur and Coochbehar districts of West Bengal, on the west by Uttar Dinajpur and Darjeeling districts of West Bengal and Purnea district of Bihar, while Assam occurs on the east. The river Sankosh separates Jalpaiguri from the Goalpara district of Assam. Administratively, as per the 2011 Census records, Jalpaiguri district consists of three sub-divisions, viz. Sadar, Mal and Alipurduar.

These sub divisions consist of 13 Community Development (CD Blocks), 17 police stations, 756 Mouza and 4 Municipalities (Census of India, 2011). From 2014, the erstwhile Jalpaiguri district has been divided into – Jalpaiguri and Alipurduar districts (Figure no. 1). From 2014, the former Jalpaiguri district has been divided into –Jalpaiguri and Alipurduar.

Objectives of the Study

Present paper has been high light on the following study:

1. To analyse the temporal flood damage impact assessment from the year 1970 to 2012.
2. To find out the damage threshold and hazardous condition over 43 years.
3. To analyse the spatial (block-wise) flood impact assessment for the year 1998.
4. To find out the probability of damage in single flood event.

Methodology for the work

The FIA is based on the following parametric data such as, House damaged fully and partially (P1), Area affected by flood (P2), Size of population affected by flood from time to time (P3), Cropped area damaged in hectare [ha] (P4), Infrastructural loss (value in lakh) (P5).

All the data on damage impacts have been standardized by calculating z-scores for making them dimensionless and scale-free, then those z-sores have been added to make composite Z score which have subsequently being plotted in bar-graph formation and line graph formation. Highest value of Z score has been observed as rank 1. Average value of composite Z score is plotted in the graph. With the value of Mean ± SD, the Damage Threshold Line (DTL) is drawn.

Spatial Variation of flood hazard damage has been analyzed for the year of 1998 because in this year flood damage was very high in the light of damages experienced during the recent past. On the basis of the above block-wise flood damage impact mapping for the year 1998 has been done on the basis of z-scores data.

Magnitude of damage analysis has been done by Exceedance Probability (EP). Here, T = n+1/ m, where T = return period in years; m = rank, n = no. of years in record. The probability of occurrence of flood damage of a given magnitude is expressed by taking the inverse of the Return Period (P) i.e., P = 1/T.

Discussion and Result

Damage to human life, properties and infrastructure caused by flood hazard are measurable components of the flood hazard intensity. According to the composite Z score value, the impact of damage may be classified into six categories viz., they are: Very High (10 to 7), Moderately High (7 to 4), High (4 to 1), Moderate (1 to -2), Low (-2 to -5), and Very low (-5 to -8) (Fig. 2). Very high impact of damage has been found in 1987 followed by 1998 and 1993. Moderately High impact of damage has been found in 1984 and 1972. High damage has been found 1983, 1982 and 1974. Moderate damage has been found in the year of 1988, 1990, 1997, 1999, 2000, 2008 and 2012. Low damage impact has been observed in 1970, 1973, 1977, 1989, 1991, 1992, 1994, 1995, 1996, 2002, 2007, 2009 and 2010. Very low damage impact has been found rest of the years, accepts 1976, 1981 and 1985 within the given span of 43 years. The lowest impact of flood has been found in these said years of 1976, 1981 and 1985.

In rank-wise distribution of the damage impact over 43 years, the year 1987 ranks first followed by 1998 and 1993. (Table 1) The average damage impact line has been drawn in the graph to show how many years of damage are above the average line. (Fig. 3) Within 43 years, if Very High, Moderately High and High flood years in the district are considered, it is found that there are 17 years annual flood events lying above the average flood damage impact line.

As mentioned in the methodology before, an average value of composite Z score is plotted in the graph. (Fig. 3) With the value of Mean ± SD the Damage Threshold Line (DTL) is drawn. Damage threshold line is the line how far the district will take flood as an event with compromise their damage.

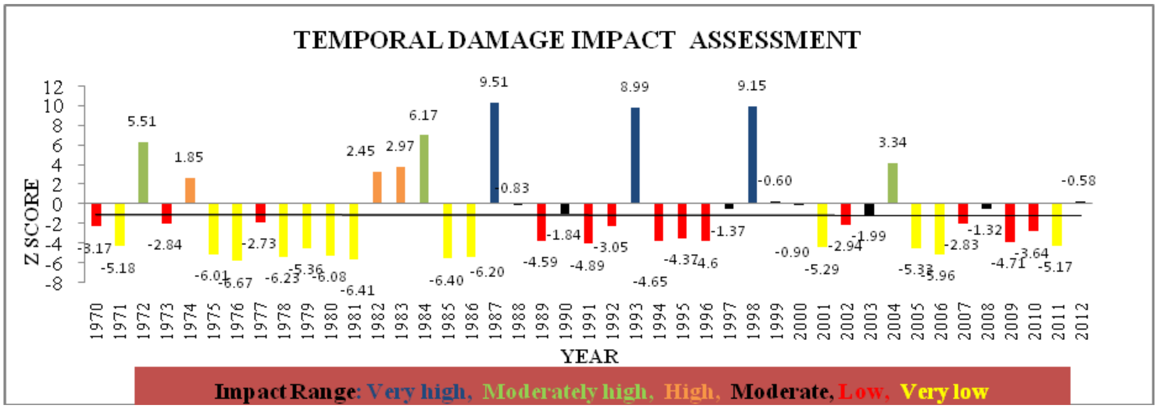

Fig. 2. Year-wise Damage Impact Assessment According to Composite Z Value.

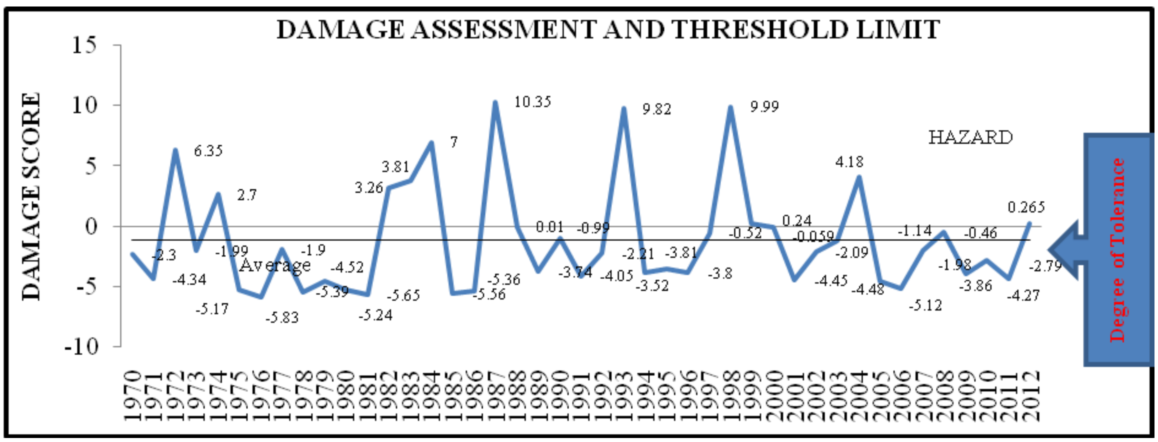

Fig. 3. Flood Hazard Assessment and Zone of Tolerance (*Source: Prepared by author)*

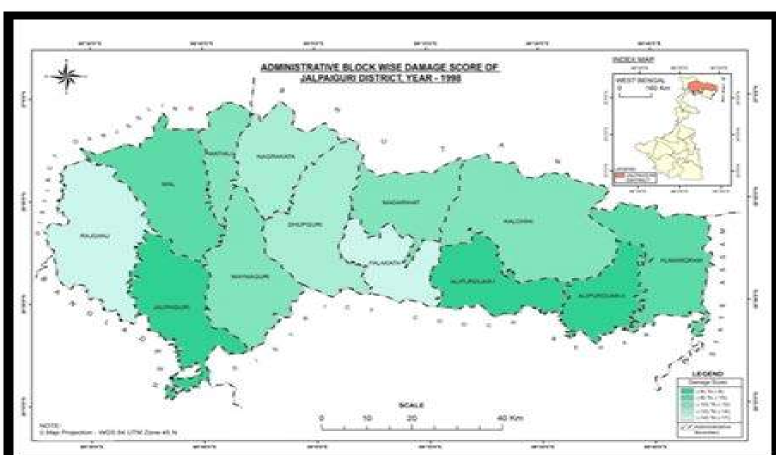

Fig. 4. Spatial Distribution of Flood Damage Score, 1998 (*Source: Prepare by author)*

Table 1. Z score of damage variables.

Year	P1 Z score	P2 Z score	P3 Z score	P4 Z score	P5 Z score	Composite Score	Rank
1970	-0.83	-2.95	-0.86	-0.74	-0.41	-3.14	
1971	-1.37	-1.69	-1.02	-0.87	-0.238	-5.1	
1972	1.78	0.98	0.29	1.66	0.79	5.50	5
1973	-0.62	-1.03	-0.59	-0.29	-0.31	-2.84	
1974	1.39	-0.59	-0.35	0.73	0.67	1.86	9
1975	-1.63	-1.67	-0.94	-0.99	-0.77	-6.01	
1976	-1.60	-1.69	-1.17	-1.23	-0.98	-6.67	
1977	-1.36	-1.54	-0.49	0.39	0.27	-2.74	
1978	-1.34	-1.69	-1.15	-1.13	-0.93	-6.23	
1979	-1.57	-1.84	-0.70	-0.29	-0.96	-5.37	
1980	-1.59	-1.52	-0.97	-1.04	-0.98	-6.08	
1981	-1.61	-1.53	-1.17	-1.21	-0.98	-6.49	
1982	1.60	-1.56	1.74	1.41	-0.77	2.42	8
1983	0.94	-0.79	1.04	0.62	1.17	2.97	7
1984	0.19	1.44	1.29	1.59	1.65	6.17	4
1985	-1.47	-1.68	-1.04	-1.20	-1.00	-6.4	
1986	-1.60	-1.58	-0.96	-1.05	-1.01	-6.21	
1987	0.45	1.82	2.10	2.47	2.66	9.51	1
1988	-0.95	-1.57	0.63	0.09	0.96	-0.83	
1989	-1.29	-1.60	-0.44	-0.35	-0.91	-4.59	
1990	-1.21	-1.69	.94	0.68	-0.56	-1.84	
1991	-1.59	-1.77	-0.42	-0.50	-0.61	-4.89	
1992	-1.47	-1.78	-0.56	-0.07	0.84	-3.05	
1993	1.15	0.92	2.26	2.32	2.33	8.98	3
1994	-1.31	-1.69	-0.76	-0.43	-0.45	-4.65	
1995	-1.59	-1.59	-0.49	-0.36	-0.32	-4.37	
1996	-1.59	-1.60	-0.64	-0.41	-0.39	-4.65	
1997	-1.08	-1.69	0.76	0.42	0.22	-1.37	
1998	0.96	1.22	2.12	2.29	2.55	9.15	2
1999	-1.42	-0.80	0.59	0.09	0.93	-0.60	
2000	-1.38	-0.72	0.65	0.19	0.35	-0.90	
2001	-1.37	-1.74	-0.92	-0.63	-0.62	-5.29	
2002	-1.16	-1.79	0.00	-0.21	0.23	-2.93	
2003	-0.54	-1.55	0.56	0.15	-0.60	-1.99	
2004	-0.09	0.33	1.43	1.21	0.46	3.34	6
2005	-1.38	-1.66	-0.69	-0.89	-0.69	-5.33	
2006	-1.39	-1.79	-0.99	-0.98	-0.81	-5.96	
2007	-1.39	-1.74	0.27	-0.18	0.21	-2.83	
2008	-1.35	-1.69	0.76	0.47	0.51	-1.3	
2009	-1.37	-1.82	-0.34	-0.48	-0.68	-4.71	
2010	-1.39	-1.61	0.78	-0.62	-0.78	-3.64	
2011	1.26	-1.66	-0.73	-0.66	-0.81	-5.12	
2012	-0.52	-1.10	0.20	0.048	0.79	-0.58	10

Ten highest rank are given in Table no. 1, Z Score of P1=Damage Houses, P2= Damage Cropped Area (000 hectare), P3=Affected Area (sqkm), P4= Affected Population, P5=Infrastructural Loss (Lakh). *Source: Calamity Assessment (CA-II) report from Disaster Management Section, Jalpaiguri, (1998-2012); NBFCC (North Bengal Flood Control Commission-1970-1997); and Central Water Commission (CWC-1970-1997).*

Table 2. Exceedance Probability of damage variable composite score.

Year	Composite Score	Descending order	Rank(m)	r= (n+1)/m	P = 1/r	p*100
1970	-3.14	9.51	1	44	0.022727273	2.272727273
1971	-5.18	9.15	2	22	0.045454545	4.545454545
1972	5.51	8.98	3	14.66666667	0.068181818	6.818181818
1973	-2.84	6.17	4	11	0.090909091	9.090909091
1974	1.86	5.51	5	8.8	0.113636364	11.36363636
1975	-6.01	3.34	6	7.333333333	0.136363636	13.63636364
1976	-6.67	2.97	7	6.285714286	0.159090909	15.90909091
1977	-2.74	2.42	8	5.5	0.181818182	18.18181818
1978	-6.23	1.86	9	4.888888889	0.204545455	20.45454545
1979	-5.37	-0.577	10	4.4	0.227272727	22.72727273
1980	-6.08	-0.6	11	4	0.25	25
1981	-6.49	-0.83	12	3.666666667	0.272727273	27.27272727
1982	2.42	-0.9	13	3.384615385	0.295454545	29.54545455
1983	2.97	-1.3	14	3.142857143	0.318181818	31.81818182
1984	6.17	-1.37	15	2.933333333	0.340909091	34.09090909
1985	-6.4	-1.84	16	2.75	0.363636364	36.36363636
1986	-6.21	-1.99	17	2.588235294	0.386363636	38.63636364
1987	9.51	-2.74	18	2.444444444	0.409090909	40.90909091
1988	-0.83	-2.83	19	2.315789474	0.431818182	43.18181818
1989	-4.59	-2.84	20	2.2	0.454545455	45.45454545
1990	-1.84	-2.93	21	2.095238095	0.477272727	47.72727273
1991	-4.89	-3.05	22	2	0.5	50
1992	-3.05	-3.14	23	1.913043478	0.522727273	52.27272727
1993	8.98	-3.64	24	1.833333333	0.545454545	54.54545455
1994	-4.65	-4.37	25	1.76	0.568181818	56.81818182
1995	-4.37	-4.59	26	1.692307692	0.590909091	59.09090909
1996	-4.65	-4.65	27	1.62962963	0.613636364	61.36363636
1997	-1.37	-4.65	28	1.571428571	0.636363636	63.63636364
1998	9.15	-4.71	29	1.517241379	0.659090909	65.90909091
1999	-0.6	-4.89	30	1.466666667	0.681818182	68.18181818
2000	-0.9	-5.12	31	1.419354839	0.704545455	70.45454545
2001	-5.29	-5.18	32	1.375	0.727272727	72.72727273
2002	-2.93	-5.29	33	1.333333333	0.75	75
2003	-1.99	-5.33	34	1.294117647	0.772727273	77.27272727
2004	3.34	-5.37	35	1.257142857	0.795454545	79.54545455
2005	-5.33	-5.96	36	1.222222222	0.818181818	81.81818182
2006	-5.96	-6.01	37	1.189189189	0.840909091	84.09090909
2007	-2.83	-6.08	38	1.157894737	0.863636364	86.36363636
2008	-1.3	-6.21	39	1.128205128	0.886363636	88.63636364
2009	-4.71	-6.23	40	1.1	0.909090909	90.90909091
2010	-3.64	-6.4	41	1.073170732	0.931818182	93.18181818
2011	-5.12	-6.49	42	1.047619048	0.954545455	95.45454545
2012	-0.577	-6.67	43	1.023255814	0.977272727	97.72727273

Red indicates nine high Z value.

n=43 Yellow indicates three low Z value.

Source: Calamity Assessment (CA-II) report from Disaster Management Section, Jalpaiguri, (1998-2012); NBFCC (North Bengal Flood Control Commission-1970-1997); and Central Water Commission (CWC-1970-1997)

Table 3. Administrative Block Wise Damage Score (Higher value indicate rank 1).

Block	P1 Z score	P2 Z score	P3 Z score	P4 Z score	P5 Z score	P6 Z score	Composite Z score	Rank	Range Wise
Rajganj	-3.35	-3.82	-3.35	-1.68	-1.75	-2.77	-16.73	13	5
Sadar	-1.52	-1.37	-080	-1.43	1.61	-2.87	-6.38	1	1
Maynaguri	-2.31	-2.93	-0.82	-1.68	-1.29	-1.57	-10.61	7	3
Mal	-1.54	-2.24	-2.10	-0.59	-1.06	-1.58	-9.12	5	2
Matiali	-1.81	-1.92	-3.88	-1.32	0.29	-2.78	-11.44	9	3
Nagrakata	-1.29	-2.74	-2.39	-0.67	-0.97	-4.43	-12.49	10	4
Dhupguri	-2.01	-0.72	-2.04	-1.52	-1.82	-4.90	-13.01	11	4
Madarihat	-0.97	-2.74	-0.85	-1.69	-1.73	-2.48	-10.45	6	3
Falakata	-2.51	-1.11	-3.16	-1.39	-1.99	-4.31	-14.47	12	5
Alipurduar I	0.39	-0.98	-2.43	0.92	-1.14	-3.39	-6.64	2	1
Alipurduar II	-1.74	-0.94	-2.32	1.30	-1.17	-2.87	-7.74	3	
Kalchini	-2.19	-1.10	-2.17	-1.39	-1.64	-2.82	-11.32	8	3
Kumargram	-0.00	-0.84	-1.10	-1.68	-1.60	-3.13	-8.37	4	2
Class Range of Damage Score: 1) (-6)-(-8), 2) (-8)-(10), 3) (-10)-(-12), 4) (-12)-(-14), 5) (-14)-(-17)									

The mean + SD line is marked as the upper limit of the tolerance beyond which above flood is an in tolerable hazard. Between the lines of Mean + SD (3.35) and Mean-SD (-5.61), there is the region of tolerance. So, it is clear that within these 43 years the hazardous flood event has been found only in 7 years. (Fig. 3)

Administrative block wise damage analysis has been done for the year of 1998. The year 1998 has been selected due next higher damage score within 43 years. On the basis of administrative block C(A) II record of 1998 flood impact z-scores spatial variation of flooding damage character within the study area can be mapped. According to the composite score (Table 4) of the administrative block the first rank stood Jalpaiguri Sadar followed by Alipurduar I and II. Spatially lowest damage has been found in Rajganj followed by Dhupguri and Falakata. Average composite score of damage has been found -10.67 and above this score the main blocks are Jalpaiguri Sadar, Alipurduar I, Alipurduar II, Kumargram and Mal block. Range wise spatial distribution of the damage for the year 1998 has been prepared. Range wise spatial distribution of the damage for the year 1998 has been prepared. The year 1998 has been selected due next higher damage score within 43 years. On the basis of administrative block C(A) II record of 1998 flood impact z-scores spatial variation of flooding damage character within the study area can be mapped. According to the composite score (Table no. 3) of the administrative block the first rank stood Jalpaiguri Sadar followed by Alipurduar I and II. Spatially lowest damage has been found in Rajganj followed by Dhupguri and Falakata. Average composite score of damage has been found -10.67 and above this score the main blocks are Jalpaiguri Sadar, Alipurduar I, Alipurduar II, Kumargram and Mal block. Range wise spatial distribution of the damage for the year 1998 has been prepared.

Exceedance Probability has been derived with the composite Z score values to find out the probability of damage in the district. It is clear from the Table no. 2 that, the damage of flood in the district corresponding to the Exceedance Probability (EP) of 75% and 50% is read as Z score with (-5.29) means very low damage and Z score value with (-3.05) means low damage respectively. 25% chance of damage probability corresponding to Z score value (-0.6) means high to very high damage. It can be expected that, high to very high damage will be found in at intervals of 25 years within 100 years.

Conclusion

It has been concluding that the damage by the flood hazard in the district of Jalpaiguri is an annual phenomena but its intensity vary from year to year. Some of the year the damage has been crossed the damage threshold limit and create a hazardous condition for the district. Damage not only varies in temporal span but also vary in spatial dimension in the district.

References

Fewtrell, L., Kay, D. and Ashley, R. (2008). Flooding and health - an evaluation of the health impacts of urban pluvial flooding in the UK. *In:* Fewtrell, L. & Kay, D. (eds.) *Health Impact Assessment for Sustainable Water Management.* IWA Publishing.

Messner, F. and Meyer, V. (2006). Flood damage, vulnerability and risk perception of challenges for food damage research. In: Schanze J, Zeman E, Marsalek J (eds) Flood risk management of hazards, vulnerability and mitigation measures. Springer. Pp.149-167.

Paul, A. and Chatterjee, S. (2010). A manual for coastal risk assessment in Bay of Bengal coast" 4th Session of the IAG Working Group on Geomorphological Hazards (IAGEOMHAZ) & International workshop on Geomorphological hazards.

Smith, K. and Ward, R. (1998). Floods: Physical Processes and Human Impacts". Chichester and New York: John Wiley.

Smith, K. (2001). Environmental Hazards, assessing risk and reducing disaster. Third edition, Routledge, London and New York. Pp. 69 -72.

Verger, P., Rotily, M., Hunault, C., Brenot, J., Baruffol, E. and Bard, D. (2003). Assessment of exposure to a flood disaster in a mental-health study. *J. Expo. Anal. Environ. Epidemiol.* 13**:** 436-442.

White, G. F. (1974). Natural Hazards: Local, National, Global. New York: Oxford University Press.