J. Environ Science & Engg., Vol. 57, No. 3, P 230-238, July 2015

Spatial and Temporal Characteristics of Flood in Kaithal District Haryana, India

PUSHPENDRA SINGH RAJPOOT*+, AJAY KUMAR** AND R.K.TRIVEDI***

Floods are reoccurring natural hazard. Major part of Kaithal district of Haryana, is drained by Ghaggar River and its tributaries and faces the problem of flood. All the tributaries of Ghaggar River meet in this region and brings huge amount of sediments and blocks the drains. Present study presents the outcome of flood frequency analysis using rainfall data and by integration of different parameters (slope, landform, soil, drainage and land use/land cover). Flood risk zone spatial analysis showing high, moderate and low flood risk zone is done using Remote Sensing & GIS techniques and discharged data is also considered. Frequency and recurrence interval shows that low to moderate flood risk is a regular phenomenon and extreme moderate to high flood occurs three or four times in two decades. High flood risk zone is found in northern part (Guhla block) and covers an area of about 19%, a large northern part of Kaithal district. Moderate flood risk zone is found in north along with the high flood risk zone and covers about 7% area. Remaining 74% of the study area is characterized by no/low flood risk zone.

Key words: *Spatial, temporal, land use/land cover, flood distribution, Kaithal and Ghaggar river*

Introduction

Floods are a natural phenomenon that occur when water from rainfall, snow melt, dam failure or any combination of these is released into a stream at rates that exceed the transfer and storage capacity of the channel. Flooding is responsible for both annual loss of large number of life and huge amount of property. In Kaithal district of Haryana in Ghaggar river basin, flood is one of the regularly occurring disaster and its effects are getting worse.

Ghaggar basin is also characterized with number of palaeo channels which are in the low-lying part of the alluvial plains within basin; they act as conduits and become instrumental in carrying the floodwaters[1]. Studies on flood risk assessment in the part of Kosi River basin are conducted by integrating hydrological, geomorphological, land cover, topographic and social (population density) parameters using RS & GIS technique to obtain the Flood Risk Index (FRI)[2]. Present study is an attempt to analyze the temporal and spatial characteristics and impact of flood risk in Kaithal district to help the administrators and planners for making development plan to minimizing the losses due to flood.

Kaithal district is situated between 29° 51' 49" to 30° 12' 40" N latitude and 76° 10' to 76° 29' 10" E longitude. It is a part of Ghaggar River and its major tributaries i.e. Markanda, Tangri and Patialewali basin Saraswati, Pachhisdhara are the few important tributaries. Total basin area of Ghaggar is 8024.06 sq km. The normal annual rainfall is 563 mm and about 85% of annual rainfall is contributed by south-west monsoon during last week of June and end of September. July and August are the wettest months. Rest 15% rainfall is received during non-monsoon period.

*Research Scholar, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, M.P. India
**HOD (Geology), Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, M.P. India
***HOD (Geology), Dr. H. S. Gour Vishwavidyalaya Sagar, M.P. India
Corresponding author : prajpoot179@gmail.com

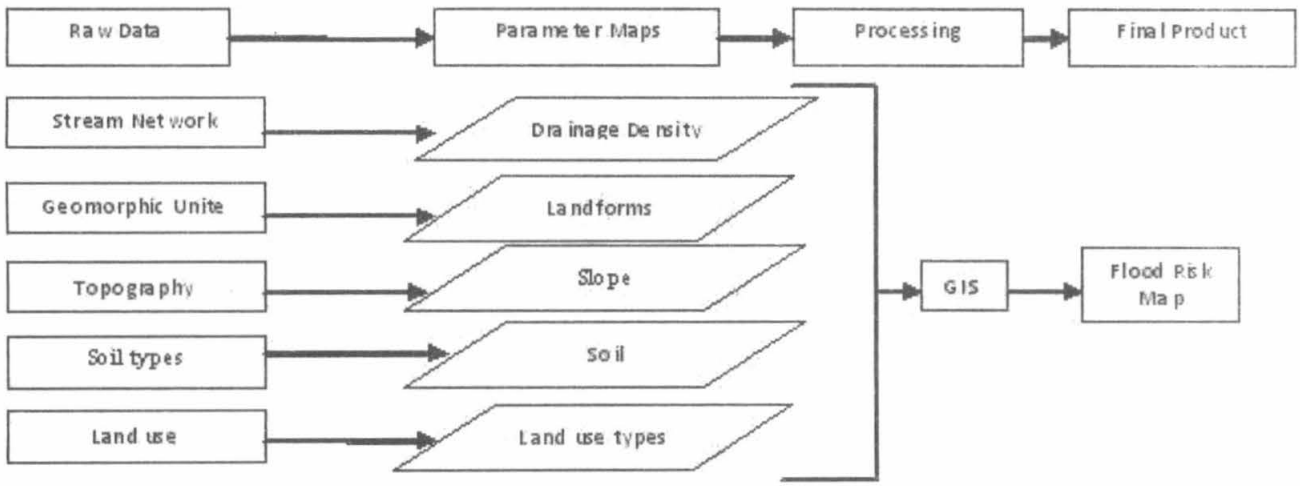


Fig 1: Methodology for flood risk mapping

Materials and methodology

To study the temporal interval of flood intensity, 41 years rainfall data (Source. Haryana Irrigation Department, Chandigarh) has been used. Spatial analysis of different categories of flood distribution is done using multicriteria evaluation (MCE) method [3&4] using LANDSAT data, ETM+, 13 Nov 2005 [5,6&7]. Topographic map, Survey of India (SOI) is used for preparation of different thematic layers such as slope, landform and drainage. GIS application is fully used for producing, analyzing and integrating spatial data to prepare a flood risk map (Fig.1).

Result and discussion

To assess the flood situation in time and space, collected rainfall data is given in Table – 1 and details of drainage system (Map 1), drainage density (Map 2) and landforms (Map 3) are shown. Using the above details, discharge data in cumecs is calculated for points (1) Ghaggar Bund at RD 140 Cheeka Patiala Road, (2) Ghaggar River RD 117500 near Village Bhatian and (3) Ghaggar Bund near Chichanwala (Table 2) for various levels of rainfall <600 mm, 600 – 700 mm and >700 mm and floods are classified as no flood, moderate flood and high flood respectively. Frequency of different category of flood year wise is given in Table – 3 & Fig 2 & 3.

To obtain temporal characteristics and flood risk zone (spatial characteristics) of study area, analysis and results of hydrological study of 41 years rainfall record are given below.

Temporal studies of flood, based on yearly rainfall (mm) data (Table 1) and flood trend are shown in Fig. 3. Flood is natural phenomenon which covers a vast area. According to rainfall data of 41 years, the highest rainfall is found in 1998 & 2010 and highest flood intensity. Moderate flood is found in 1971, 75, 76, 77, 88, 93, 95, 98 and 2007. Discharge data as calculated using Boston Society Formula (Haryana Irrigation Department, Chandigarh Report- Flood Management and Drainage System in Haryana) at three locations, (1) Ghaggar Bund at RD 140 Cheeka Patiala Road, (2) Ghaggar River RD 117500 near Village Bhatian and (3) Ghaggar Bund near Chichanwala, are shown in the map. Discharge rate at these different locations of different flood level (low, moderate and high) is given in Table 2 and summarized in Table 6. Table 2 shows that different locations for rainfalls below 600 mm, 600 – 700 mm and above 700 mm the discharge (cumsec) is different. At Ghaggar Bund near Chichanwala highest discharge rate is achieved when Ghaggar Bund at RD 140 Cheeka Patiala Road and Ghaggar River RD 117500 near Village Bhatian, discharge is high at a same time high causing high flood level situation.

Table 1: Rainfall data of study area *(Source. Haryana Irrigation Department, Chandigarh)*

Years	Rainfall (mm)
1970	552.4
71	727.5
72	418.5
73	548
74	333.9
75	756.6
76	647.8
77	715.8
78	753.5
79	277.4
80	644.2
81	523.4
82	378.6
83	701.1
84	539.5
85	606.3
86	383.8
87	149.6
88	733.8
89	367
90	615.3
91	396.6
92	472.5
93	568.2
94	521.1
95	695.8
96	708.4
97	645.3
98	1100
99	515.2
2000	590.1
1	574.5
2	246.7
3	602.3
4	370.5
5	597.9
6	340.0
7	731.7
8	613.6
9	485.6
10	876.8

Table 2 : Criteria for flood intensity of Kaithal District (cumecs is calculated according to Boston Society Formula)

Sl. No	Rainfall (mm)	Flood Situation	Gauge station/basin area sq miles	Discharge in cusecs
1.	Below 600	No Flood	Ghaggar Bund at RD 140 Cheeka Patiala Road/697.03	1320
			Ghaggar river RD 117500 near Village Bhatian/1941.166	2202.5
			Ghaggar Bund near Chichanwala/3098.095	2783
2.	600 – 700	Moderate Flood	Ghaggar Bund at RD 140 Cheeka Patiala Road/697.03	3168
			Ghaggar river RD 117500 near Village Bhatian/1941.166	5286
			Ghaggar Bund near Chichanwala/3098.095	6679.2
3.	Above 700	High Flood	Ghaggar Bund at RD 140 Cheeka Patiala Road/697.03	13200
			Ghaggar river RD 117500 near Village Bhatian/1941.166	22025
			Ghaggar Bund near Chichanwala/3098.095	27830

Table 3 : Frequency and intensity of flood

Intensity of Flood	Frequency
No Flood	24
Moderate Flood	8
High Flood	9

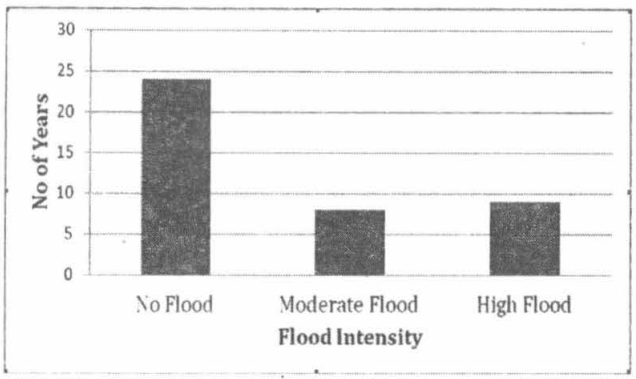


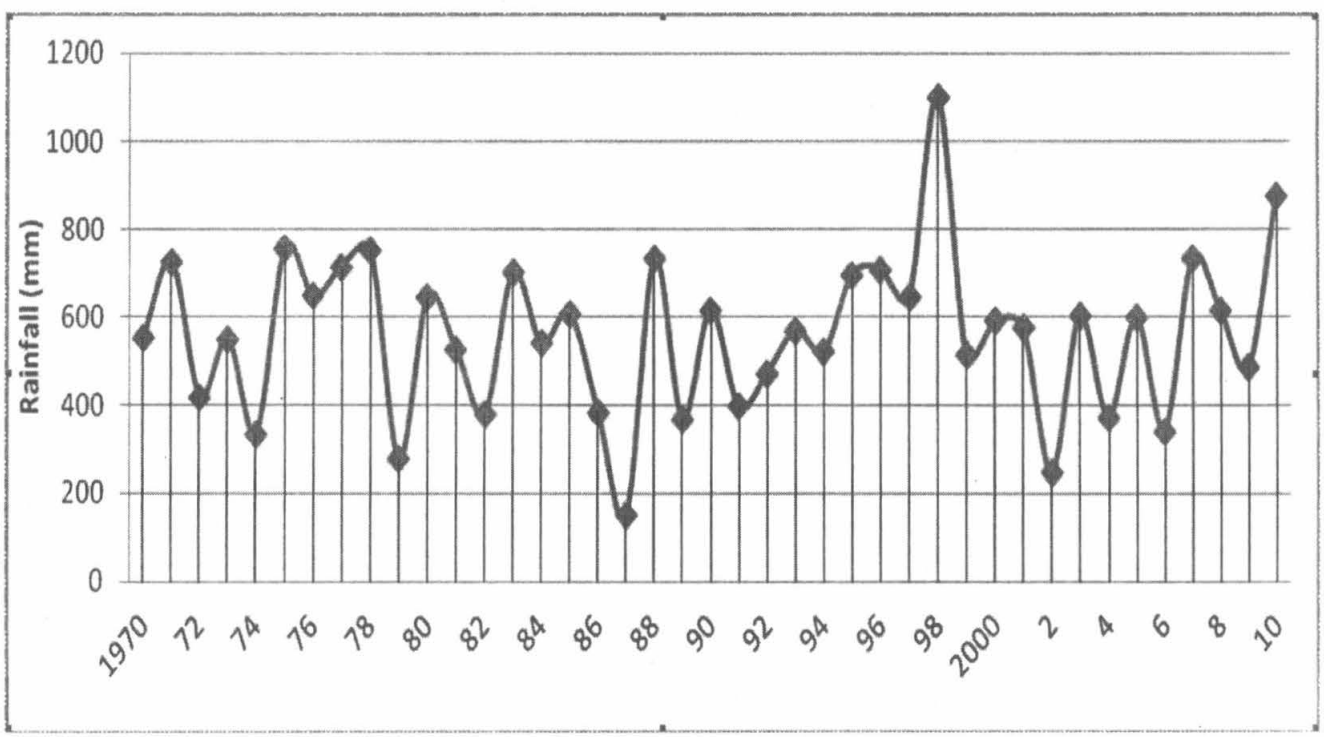
Fig 2 : Flood frequencies in Kaithal District

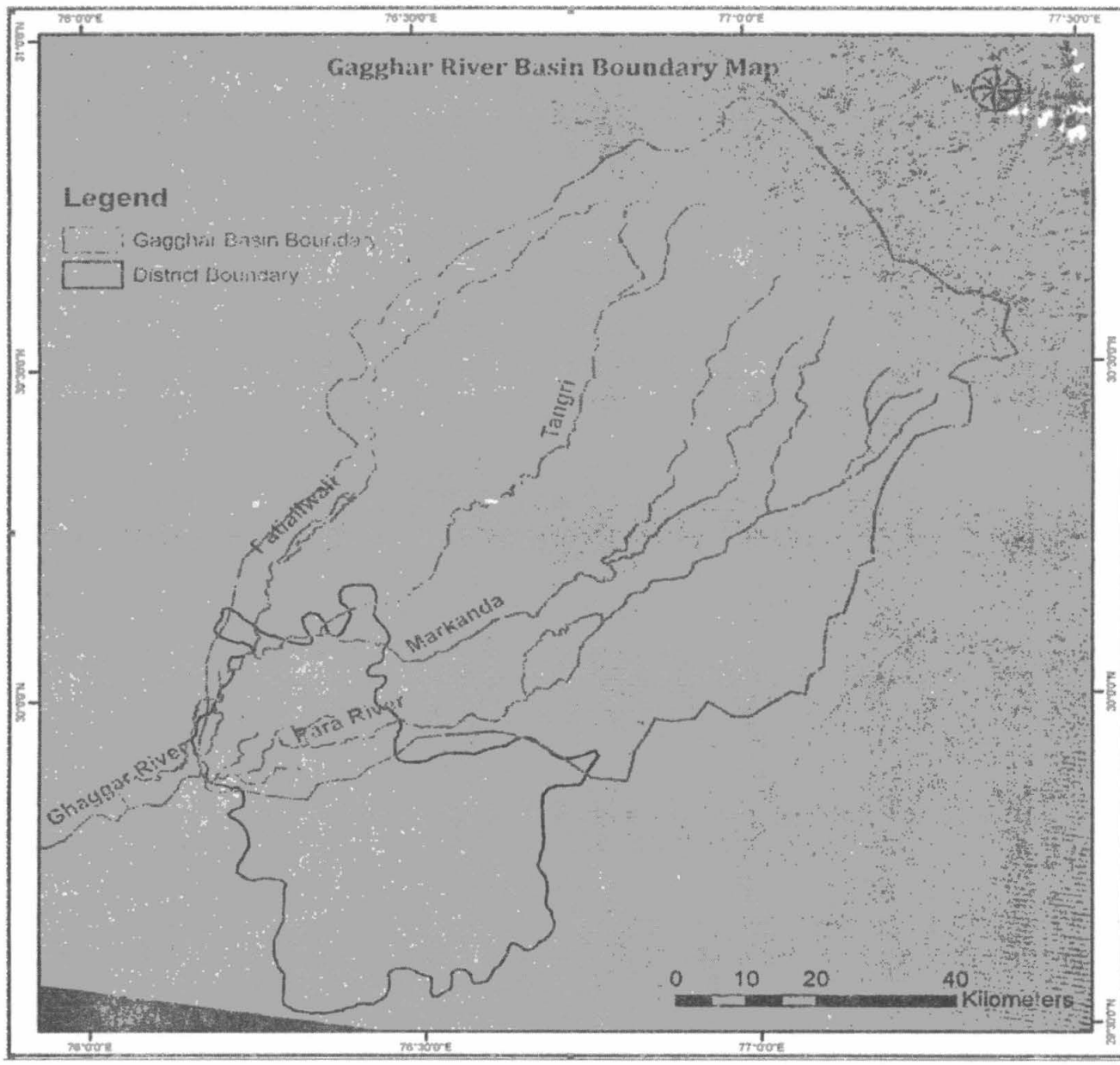
Analysis shows that extreme intensity of flood (moderate to high) is not a regular phenomenon (Fig. 2&3), it occurs three to four times in two decades and low to moderate flood is a regular phenomenon in this area. Flood recurrence and intensity is depicted from rainfall data and discharge data. This indicates that in Kaithal district flood is almost a regular occurring disaster causing loss of life and property.

Spatial distribution

Spatial distribution of different level/category of flood risk area in Kaithal District is mapped using Remote Sensing and field data by multicriteria evaluation (MCE) method[8]. Details of spatial analysis depending upon parameter, subclasses of parameter, rating and weight for overlay analysis are given in Table 4[9 & 10]. Spatial area distribution of flood risk zones is shown in Fig. 4 and given in Table 5.

Fig 3: Flood recurrence analysis using rainfall data





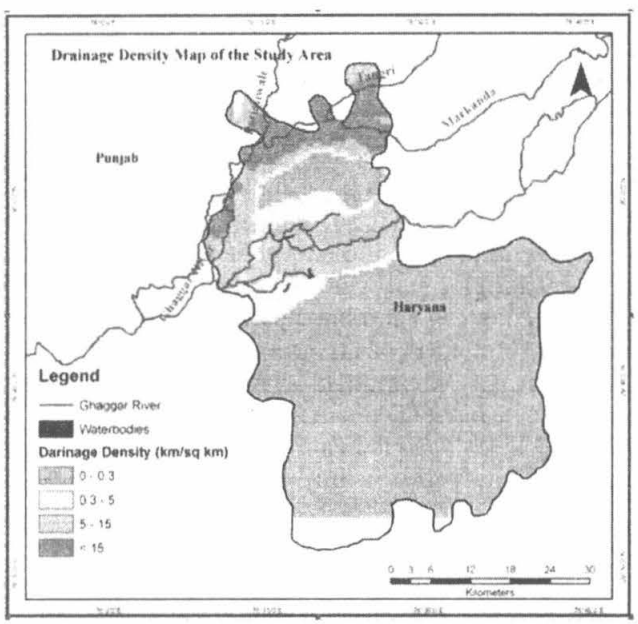
Map 1: Ghaggar river basin on satellite image LANDSAT ETM+ (13 Nov. 2005)

Analysis shows high flood risk zone is found in north western part of study area and covers about 430.11 sq km area. Moderate flood risk zone is found in north western part all along the high flood risk zone of the study area and covers about 163.30 sq km area. No/low risk zone is found in southern and central part and small area in north occupies about 1607.37 sq km area. Most affected area of Kaithal district is Guhla block the place where flooding frequency and intensity is maximum.

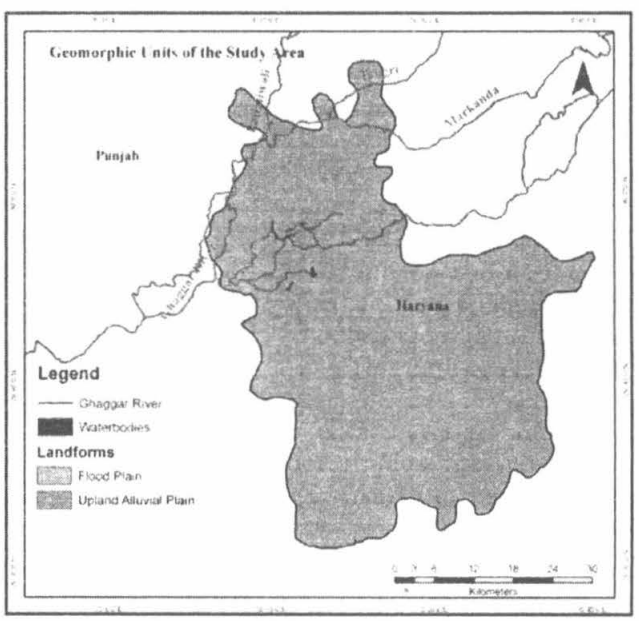
Most of flood affected area of Kaithal district is mainly concentrated in North. Frequency of flood analysis shows that out of the 41 years record no/low flood category is in 24 years, moderate flood – 8 and high flood in 9 years. This cleary indicates that in Kaithal every third / fourth year witnesses moderate to high flood.

Table 4: Parameters and weights

Parameters	Rating	Sub-class of Parameters	Weight	Area (sq km)
Slope	26.67	$0 - 1^0$	5	1606.21
		$1^0 - 3^0$	3	568.73
		$3^0 - 6^0$	2	24.89
		$6^0 - 9^0$	1	0.66.
Drainage Density	33.33	15-35.44 km/ sq.km	4	141.82
		5-15 km/sq.km	3	290.50
		0.3-5 km/sq.km	2	147.30
		0-0.3 km/sq.km	1	1559.49
Landform	20	Flood Plain	2	666.15
		Upland Alluvial Plain	1	1536.73
Land use /land cover	13.33	Water bodies	4	4.92
		Crop Land	4	1421.71
		Waste Land	3	709.15
		Vegetation	2	67.07
		Built-up	1	2.01
Soil Type	6.67	Loam	1	2139.13



Map 2 : Drainage density map of study area



Map 3 : Geomorphic units of study area

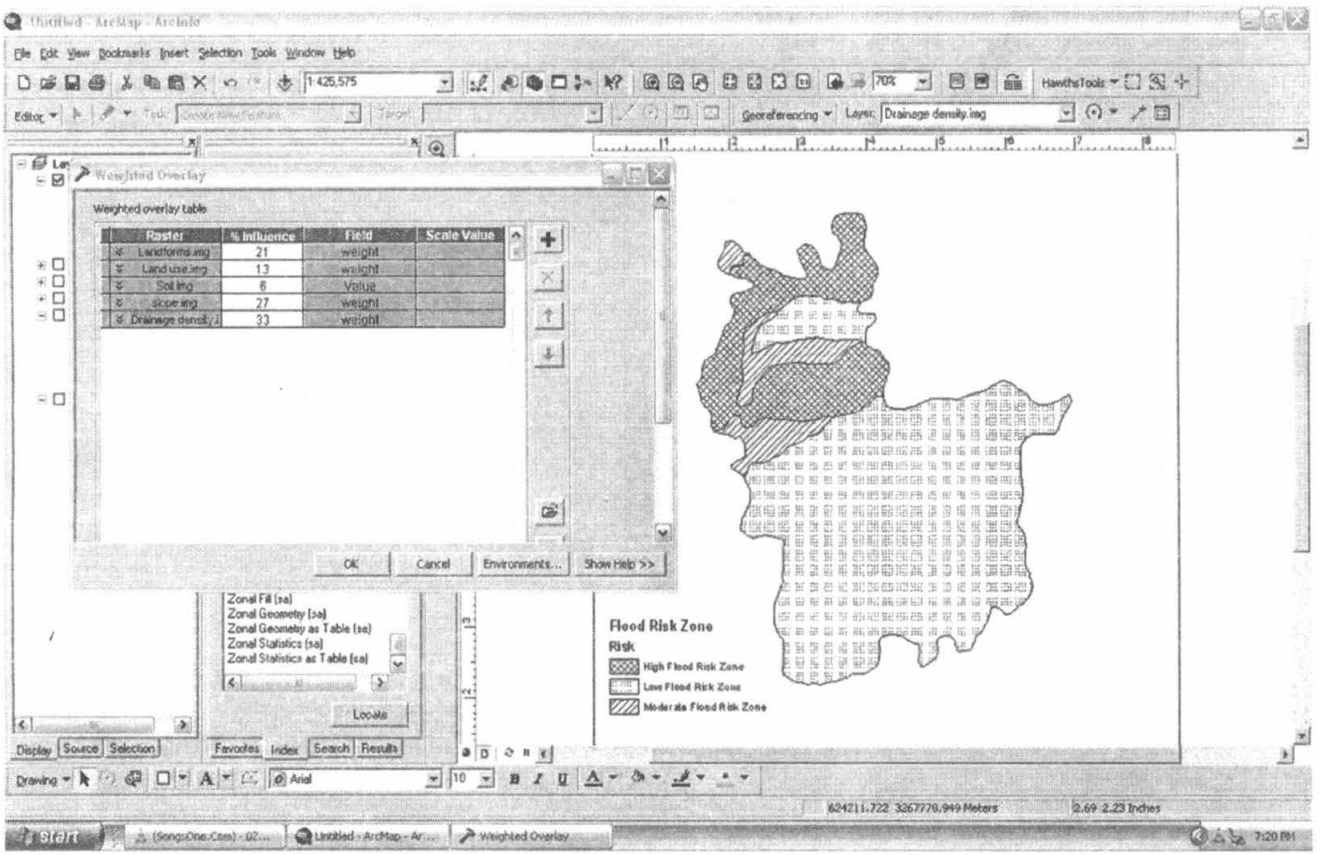


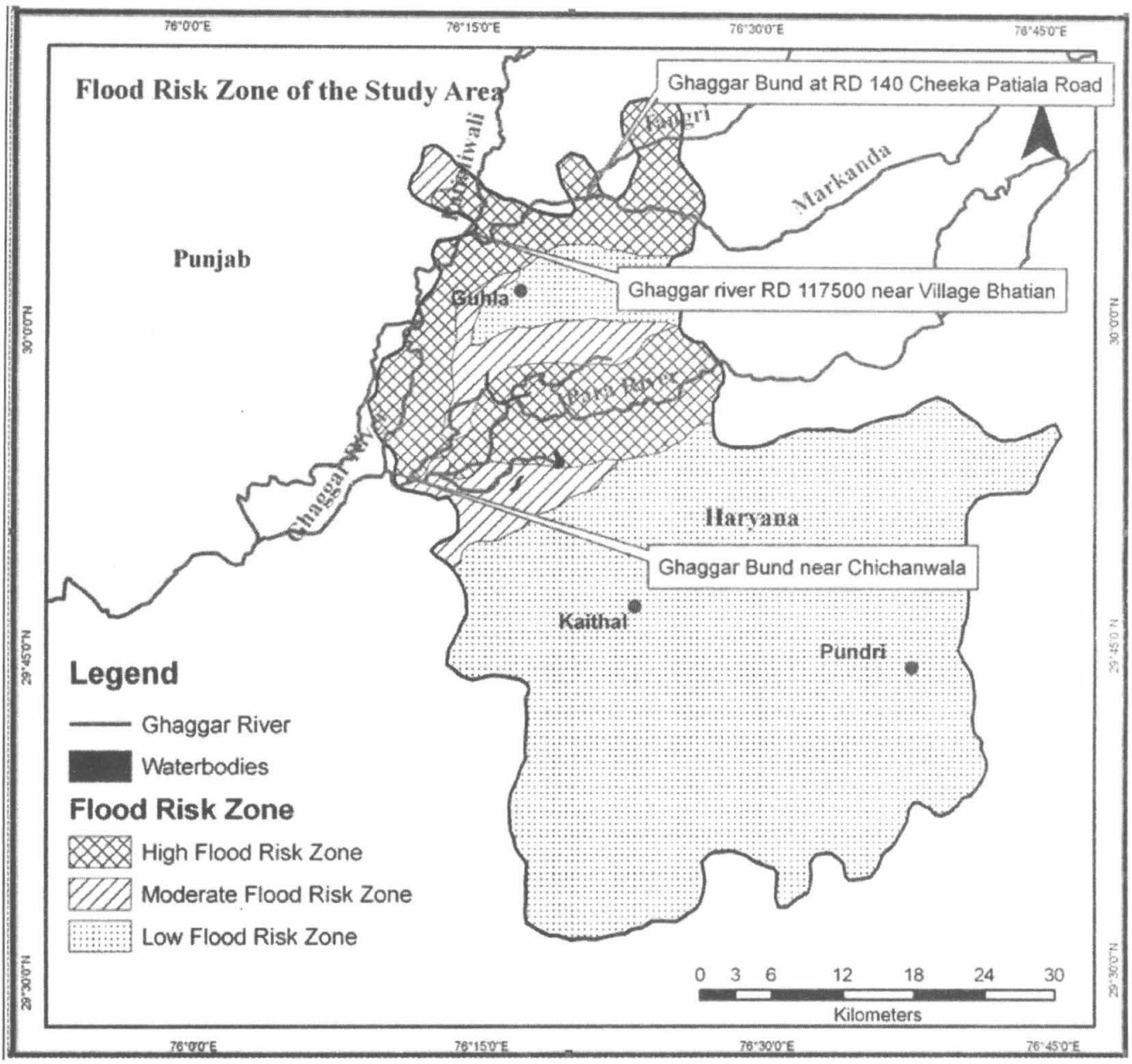
Fig 4 : Flood risk zone mapping using Weight Overlay Method

Table 5: Flood risk zone area and percentage of the study area

Flood Risk Zone	Area (sq km)	Percentage (%)
Low Flood Risk Zone	1607.37	73.04
Moderate Flood Risk Zone	163.30	7.42
High Flood Risk Zone	430.11	19.54

Table 6 : Discharge (cumecs) of different points in Kaithal district

Points	Cumecs for <600 mm rainfall	Cumecs for 600 – 700 mm rainfall	Cumecs for >700 mm rainfall
Ghaggar Bund at RD 140 Cheeka Patiala Road/697.03	1320	3168	13200
Ghaggar river RD 117500 near Village Bhatian/1941.166	2202.5	5268	22025
Ghaggar Bund near Chichanwala/3098.095	2783	6679.2	27830



Map 4 : Flood risk map of the study area

Conclusion

In Kaithal district in terms of frequency, extreme moderate to high flood level occurs three to four times in two decades and low level of flood is a regular phenomenon. Spatially high flood risk zone is mainly found in Northern part and covers 19.54 % of study area and about 65 % area of Guhla block. Moderate flood risk zone is found in North central, all within the high risk zone and covers 7.42 % of study area, about 25 % of Guhla Block. No/low flood risk zone is found in south and central part and covers about 73 % area.

References

1. Parray, Khursheed Ahmad. (2006), Ground water studies with special reference to Palaeochannels in Sangrur and adjoining areas, Punjab state India, Ph.D Thesis.

2. Sinha, R., G.V. Bapalu, G.V., Singh, L.K. and Rath, B., Flood risk analysis in the Kosi River Basin, North Bihar using multi-parametric approach of

AHP, *Indian Journal of Remote Sensing*, **36**, 293-307 (2008)

3. Heywood. I, Oliver. J and Tomlinson. S, Building an exploratory multi criteria modeling environment for spatial decision support, *International Journal of Geographical Information Science*, 7(4), 315-329 (1993)

4. Malczewski, J.(1999), GIS and multiple-criteria decision analysis, New York, John Wiley & Sons

5. Bhavsar, P., Review of Remote Sensing Applications in Hydrology and Water Sources Management in India, *Advances in Space Research*, 4(11), 193–200 (1984)

6. Rango, A. and V. V: Solomonson, Regional Flood Mapping from Space, *Water Resource Research*, 10(3), 473–484 (1974)

7. Wang, Y., Colby, J. D., and K. A. Mulcahy, An Efficient Method for Mapping Flood Extent in a Coastal Floodplain Using Landsat TM and DEM Data, *International Journal of Remote Sensing*, 23(18), 3681–369 (2002)

8. Saaty TL (1980), The Analytic Hierarchy Process. McGraw-Hill, New York, 20-25

9. Siddique MZ, Jess W Everett and Baxter E Vieux, Landfill siting using Geographic Information System: A Demonstration, *Journal of Environmental Engineering ASCE*, 122(6), 515-523 (1996)

10. Saini Surjit Singh and Kaushik. S.P., Risk and vulnerability assessment of flood hazard in part of Ghaggar Basin: A case study of Guhla block, Kaithal, Haryana, India, *International Journal of Geomatics and Geosciences*, 3(1), 42-54 (2012)