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# RISK AND VULNERABILITY ASSESSMENT OF FLOODS IN GHAGGAR RIVER BASIN

**Doctoral Dissertation Abstract (2017)**

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Floods are the most recurrent natural hazards and leading cause of economic losses worldwide. Presently, about one third of the world's land area is prone to flooding and 82 per cent population of the world is residing in such flood prone areas. Considering the overall flooding scenario at global scale, the Asian region (particularly south Asia) experiences a very high magnitude of flood events. India is second most flood affected country in the world after Bangladesh and about 12 per cent of India's geographical area is susceptible to annual flooding. Taking into account the adverse impact of floods on human society and environment, many studies have been conducted to understand the flood occurring phenomena in major perennial rivers of India. Flood hazard is very complex to understand, because it occurs not only due to physical and meteorological causes but anthropogenic factors also play major role in its occurrences.

Ghaggar, a seasonal river originating in outer Himalayas flowing through Punjab-Haryana plains, is subject to severe flooding. Over the past few decades, Ghaggar basin has undergone large scale transformations due to human interventions, affecting natural slope and drainage system very badly throughout the basin. At present larger part of the Ghaggar River is confined to embankments varying between 30 to 300 m in width. Consequently, the Ghaggar River has become more capricious resulting in abnormal floods during monsoon season in one or other part of the basin.

## Aims and Objectives

- to study the determinants of floods in Ghaggar basin.
- to delineate the flood hazard risk zones of varying intensity and identify critical flood prone areas.
- to assess bio-physical and social vulnerability to flood hazard by integrating relevant bio-physical and social factors.
- to examine holistic vulnerability by integrating bio-physical and social vulnerability.

## Database and Methodology

Flood hazard risk was analysed by integrating both remote sensing and hydrological approaches. Based on available satellite imageries of past flood occurrences during the years 1988, 1993, 1995, 2004 and 2010, GIS based layers of flood-water extent were created for each flood event separately. For the delineation of flood hazard risk zones of varying intensity (high, moderate and low),

GIS based overlay method (geometric intersection) was used to determine most and least frequently flood affected areas. Further, biophysical vulnerability index (BVI) and social vulnerability index (SVI) were calculated separately using respective relevant indicators. BVI was derived by integrating the factors like rainfall, slope, ground elevation, distance to channel, watershed size, soil types, ground water depth, drainage density, geomorphology and land use.

Similarly, village level data including number of households, total population, scheduled castes (SC) population, illiterate population, non-working population, housing condition, and amenities such as primary health sub centre, veterinary hospital, tap water/treated water, metalled or pucca road, nutritional centres (Anganwadi) and community centres were taken into account to calculate SVI. Biophysical and social vulnerability maps were prepared to understand the spatial variations in biophysical and social vulnerability in the study area. Finally, biophysical and social vulnerability maps were integrated to produce holistic vulnerability map. A causal relationship was examined by underlying biophysical and social variables at sub-district (tehsil) level, to understand the spatial variation in vulnerability across the study area between and within the tehsils. Major results of this research are highlighted as under.

## Flood Hazard Zonation in Ghaggar Basin

Based on satellite imageries of historical flood incidences viz. 1988, 1993, 1995, 2004 and 2010, flood risk vulnerability was calculated, mapped and analyzed. The result demonstrates that out of the total area (21580 $km^2$) of the basin, about 7 , 9 and 23 per cent area was found in high, moderate and low flood risk zones, respectively. Out of the total flood events under study, the tehsils of Ambala, Patiala, Moonak and Patran were affected during all the five (5-times) past flood events, followed by Guhla, Kaithal, Samana, Tohana, Ratia and Sirsa tehsils experienced four (4-times) flood events, while the tehsils of Shahabad, Rajpura, Pehowa, Sardulgarh were affected 3-times and Ellenabad and Rania tehsils 2-times by floods during the period under study.

## Biophysical Vulnerability

Biophysical vulnerability modelling results reveal that out of total 1745 villages, about 31, 25, 16, 23 and 5 per cent villages, respectively recorded very high, high, moderate, low and very low levels of biophysical vulnerability. Amongst the tehsils located in Ghaggar basin, the tehsils like Patran, Moonak, Tohana and Ratia are observed to be most vulnerable by recording high and very high levels of biophysical vulnerability. The factors such as flat and low-lying topography, lack of natural drainage, encroachments over floodplains, high ground water table, and human interference are responsible for very high biophysical vulnerability in these tehsils.

## Social Vulnerability

The SVI reveals that about 8 and 17 per cent of the total villages witnessed very high and high levels of social vulnerability, respectively. Thus, 25 per cent of the total villages having 40 per cent of total population of the study area are subject to high social vulnerability. Areas falling in the category of very high to high social vulnerability include the villages located in the tehsils of Patiala, Samana, Patran, Moonak and Sardulgarh in the state of Punjab, and Ambala, Shahabad and Kaithal tehsils located along the left bank of the

main Ghaggar river in Haryana.

## Holistic vulnerability

About 50 per cent (872 villages) villages are subject to high and very high levels of vulnerability. Very high vulnerable areas are close to the main Ghaggar River channel located in the tehsils of Patiala, Patran, Moonak, Sardulgarh and Samana of Punjab and Guhla, Tohana, Ratia, Sirsa and Ellenabad tehsils of Haryana. The intensity of vulnerability steadily declines as one moves away from main Ghaggar channel. This indicates that holistic vulnerability is mostly affected by bio-physical factors controlling the intensity of floods. However, on account of deprivation in demographic characteristics and basic amenities, several village communities are characterized with high to very high level of holistic vulnerability despite being located far away from main water channel.

Finally, based on the levels of biophysical vulnerability, social vulnerability and holistic vulnerability, priority areas were identified for policy interventions.

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