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Flood Vulnerability Analysis in Una District, Himachal Pradesh (India)

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Abstract

India is exposed to a range of natural hazards including flooding, cyclones, droughts, extreme heat, wildfires, and earthquakes (GFDRR, 2019). Between 1915 and 2015, India faced 649 disasters. The Himalayas are the most fragile regions and are acutely susceptible to floods and flash floods, particularly during the monsoon season. This region has one of the world's most complex hydrological dynamics. It encompasses the Ganga, Brahmaputra, and Indus river basins, and contributes to its vulnerability. When the hazards imposed by floods exceed the coping capabilities of the affected population, they become disastrous. District Una is situated on the bank of the Swan River, which flows north to west. During the monsoon period, rivers experience devastating floods. Furthermore, flood vulnerability assessment plays a critical role in mapping the current risk of the human landscape and allows for a comprehensive evaluation of how different socio economic factors interact and contribute to the susceptibility of the region to flooding (Kesar Chand & et al., 2024). The present study aims to determine the extent of the flood and understand the flood vulnerability in the Una district of Himachal Pradesh.

Keywords: *Flood, Vulnerability, Hazards, Human Landscape*

Introduction

Floods are one of the most prevalent natural hazards, impose considerable damage to physical environments and properties, and often result in disastrous losses of life. India is exposed to a range of natural hazards including flooding, cyclones, droughts, extreme heat, wildfires, and earthquakes (GFDRR, 2019). Between 1915 and 2015, India faced 649 disasters. Of these 649 events, 302 were caused by floods, with an average of three floods per year. This accounted for approximately 47% of the total disasters that have occurred in India over the past 100 years. (Tripathi, Prakash 2015). The Himalaya is the most fragile region and is acutely susceptible to floods and flash floods, particularly during the monsoon season. This region has one of the world's most complex hydrological dynamics. It encompasses the Ganga, Brahmaputra, and Indus river basins, and contributes to its vulnerability. When the hazards imposed by floods exceed the coping capabilities of the affected population, they become disastrous. India has lost around 80,000 lives in the last two decades due to several deadly and devastating catastrophes, such as cyclones, earthquakes, and floods, according to the UN Office for Disaster Risk Reduction (UNDRR) Report (Shreya Chaurasiya, Navneet Munoth, 2023).

Owing to the heightened flood risk in the Himalayan region, geo-environmental assessments have become particularly important. Factors such as topography, relief, slope, soil texture and type, surface runoff, channel gradient, and land use and land cover (LULC) are critical in determining a landscape vulnerability to flooding. Furthermore, flood vulnerability assessment plays a critical role in mapping the current risk of the human landscape and allows for a comprehensive evaluation of how different socioeconomic factors interact and contribute to the susceptibility of the region to flooding (Kesar Chand & et al., 2024). District Una is situated on the bank of the Swan River, which flows north to west. During the monsoon period, rivers experience devastating floods. Due to continuous silting, the bed of the swan river had risen constantly, meandering action took place, the width of the river had increased, and fertile land situated on both banks became barren due to silt deposits (Niti Ayog Report, 2020).

Study Area

Una District came into existence on September 1, 1972, in the southwestern part of Himachal Pradesh. The district, with its headquarters in Una Town, has a geographical area of 1540 sq km and covers 2.8 % of the state's area. It lies between the north latitude 31°18'00" & 31°55'00" and East longitude 75°55'00" & 76°28'00" and is covered by Survey of India degree sheet No.53A & 44M.

Towards the north, it is bounded by Kangra District; towards the north and east by Hamirpur and Bilaspur Districts, respectively; and south-west by the State of Punjab (CGWB, 2013). Administratively, the Una district is divided into two subdivisions (Una and Amb) and comprises four tehsils (Una, Amb, Bangana, and Haroli) and one sub-tehsil (Bharwain) (Fig.1).

According to the 2011 census, the district has a population of 5, 21,173 with 338 persons /sq km. The sex ratio was 976 females per 1000 males. The rural population was approximately 91%, indicating that the district had an agricultural economy. The scheduled caste and scheduled tribe populations constitute approximately 22 per cent and 2 per cent of the total population, respectively.

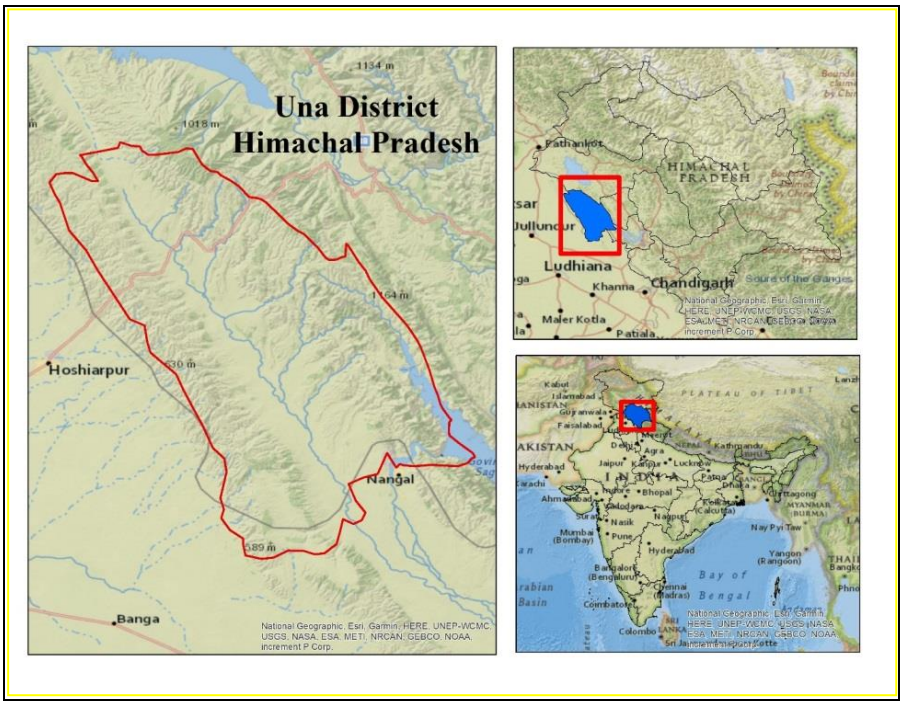


Fig.1

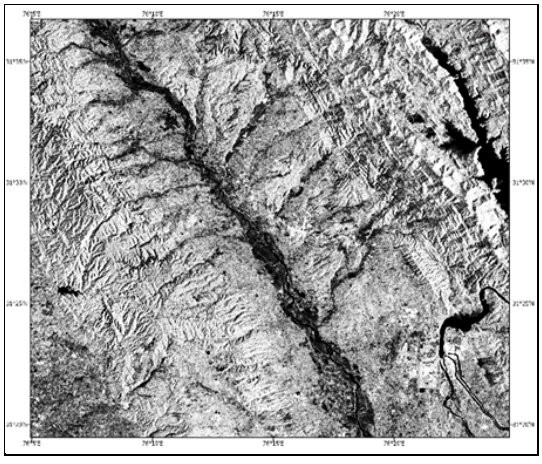
Objectives:

1. To determine the extent of the flood in Una District in 2016.
2. To analyze and understand flood vulnerability in the Una district of Himachal Pradesh State.

Data

Data	Source	Type	Resolution
Sentinel-1 SAR	ESA Copernicus Hub	Raster	10m * 10m
Landsat-9 OLI	USGS Earth Explorer	Raster	30m * 30m
Census Data	Census of India, 2011	Vector	-
IMD Disastrous Event Report	Indian Meteorological Department	Text	-

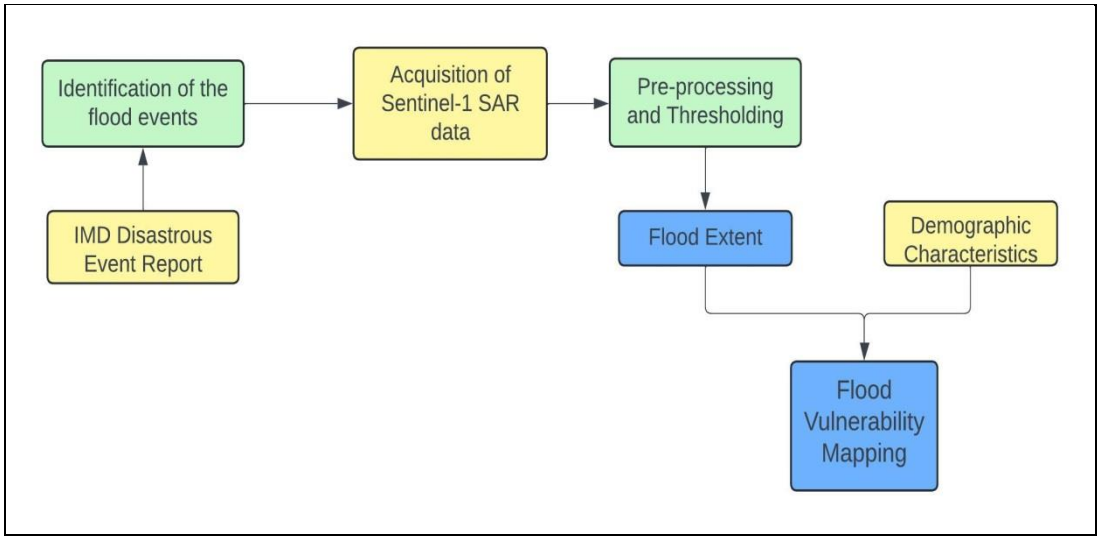
Sentinel-1 SAR Input



Satellite	Sentinel-1
Data	Synthetic Aperture Radar
Polarization	VV (Vertical Transmit, Vertical Receive)
Smoothing Filter	Median
Period	2016-08-01 to 2016-08-30

Methodology

First, the period of flood events was identified using the IMD's disaster event reports. The 2016 flood was used as the input to determine the extent of the flood in Una District. The extent of flooding was mapped using the SAR image threshold acquired during the same period. Next, village-level boundaries were overlaid on the flood extent layer to map vulnerable villages. Socioeconomic characteristics from the census data were used to derive the vulnerability of the villages.



Results

Flood Extent

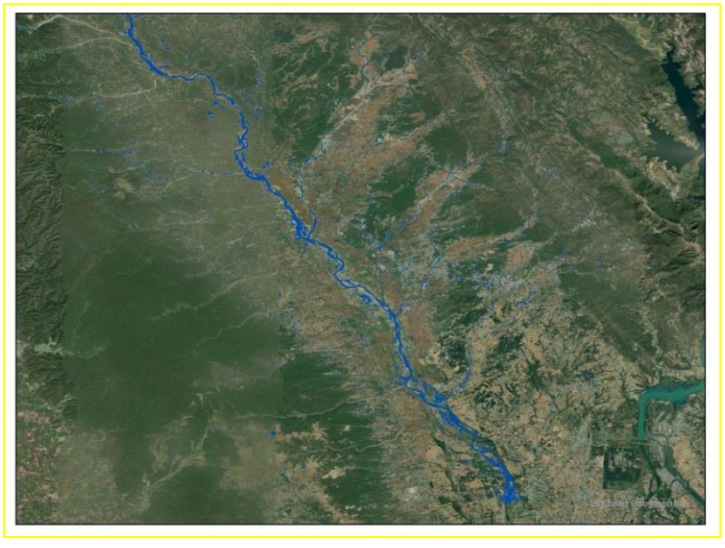
The flood extent map was derived using Sentinel-1 SAR data, in which a threshold was selected based on peak backscattering values. Flooded areas were mainly concentrated in the lower valley of the study area. The lower valley area lies under the Haroli subdivision of the district. The area is typically flooded during the summer monsoon season.

The extent of flooding was derived using Sentinel-1 SAR data acquired from the Copernicus Data Hub. Data were pre-processed using the Google Earth Engine. Thresholding was performed using a mask of the elevation data in QGIS. Finally, the flood extent map was derived by subtracting permanent water bodies.

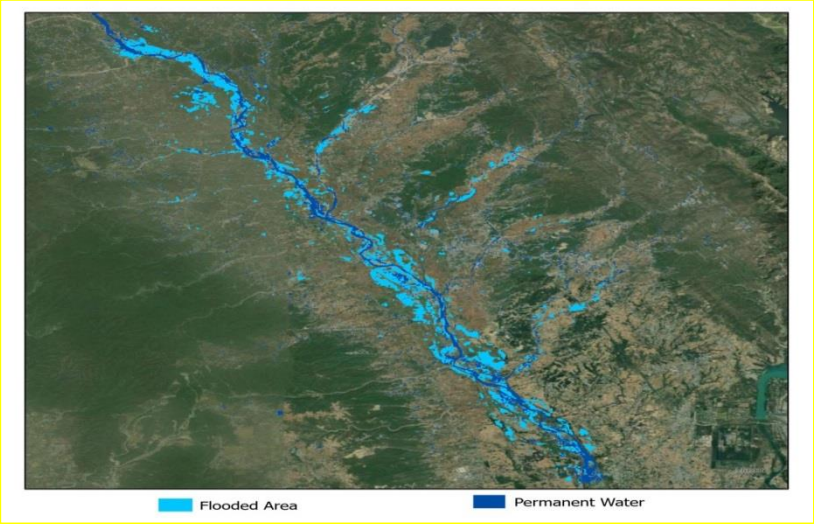
The permanent water body is the Swan River, whereas the flooded area was the result of rainfall from 1st to 30th August 2016.

Satellite	Landsat 9
Sensor	Operational Land Imager (OLI 2)
Level	2
Path/Row	148/038
Acquisition date	14/03/2024
Terrain corrected	Yes
Source	USGS Earth Explorer

Permenent Water in Swan River



Flood Extent

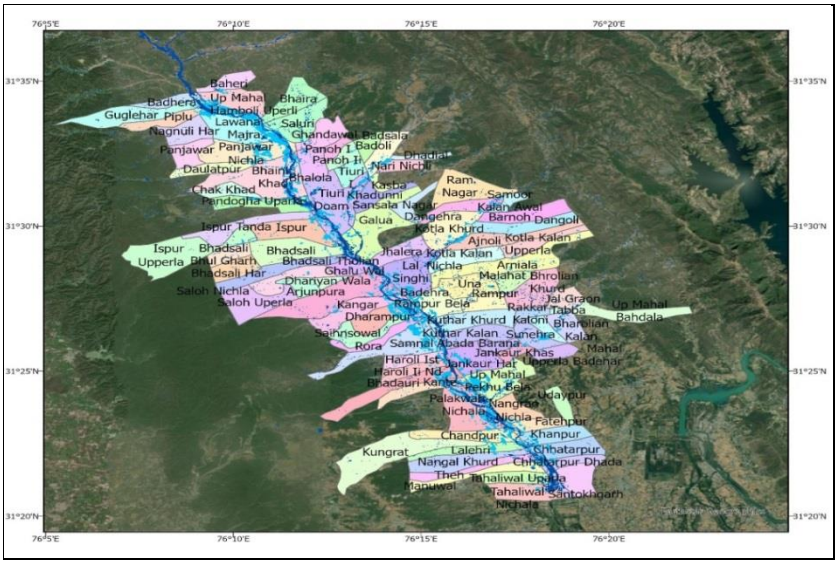


Flood Vulnerability Zonation

Flood Affected Villages

Flood inundation in the Swan River affected the adjoining villages in the neighborhood. Most of these villages are located in the lower valley of the river. A total of 96 villages were inundated by flooding during this period. At the village level, the flooded area ranged from 0.003 km² to 1.83 km². Lawana Majra experienced the highest inundation, covering a total area of 1.8378 km². The total area under flood inundation is 28.9135 km². The upper and lower sections of the lower part of the valley experience the most flooding.

Affected Villages

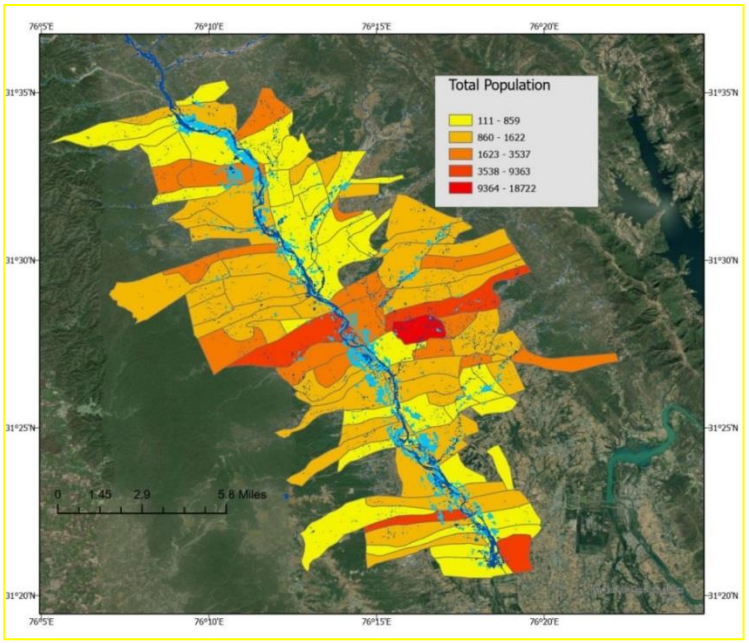


Socio-economic Vulnerability

Total Population

Population growth and distribution, especially increased population density and urbanization, increase vulnerability to disasters (Charles Perrow, 2007). Along the river, a very high population distribution was observed in Arjunpura, lalehri, and Santokhgarh; therefore, flood risk vulnerability was high in those villages, whereas moderate population vulnerability was observed in villages along the right bank of the Swan River, such as Bhaira, Jhalera, and Lalsinghi, and villages such as Panjawar, Ispur, Kangar, and Dharampur along the left side bank of the river. The remaining villages have low and very low population distributions, resulting in less flood vulnerability. Congestion, limited escape routes, and poverty in the study area are responsible for vulnerability.

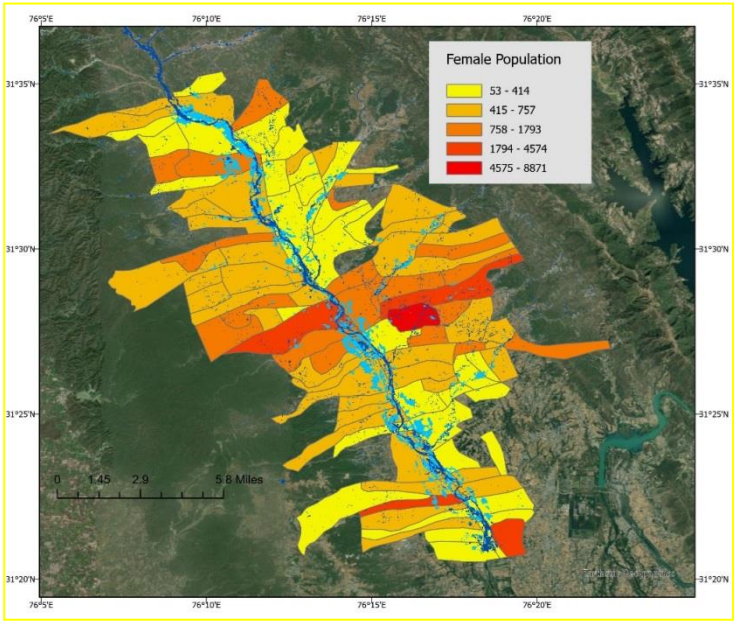
Most of the population distribution was found in villages in the middle and lower basins of the valley, which are responsible for more flood vulnerability risk than the villages in the upper basin of the Swan Valley.



Female Population

It is a well-accepted notion that women are more vulnerable to natural disasters than men are, especially in developing countries. Although population growth and distribution are important factors in producing vulnerability, those affected by disasters are equally important. Women face unique challenges during disasters. Women are more likely to recognize and respond to risk; they tend to be poorer than men and may not have the necessary resources to respond to and recover from disasters. Therefore, the socio economic status of women also determines their flood vulnerability.

The present analysis revealed that the impacts of floods were different for males and females and that females were more vulnerable. In the study area, females distributed in the villages of the middle and lower basins of the valley were also responsible for higher flood vulnerability risk than the female population in villages in the upper basin of the Swan Valley.



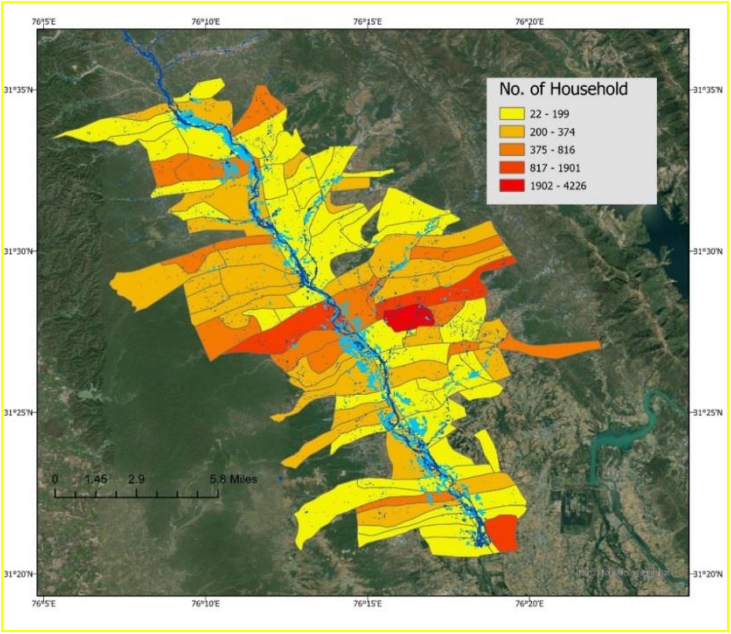
No. of Household

Household vulnerability assessment is considered an essential step toward reducing the harmful consequences of disaster risks. Adaptation helps to reduce future vulnerability (Farman Ullah et. al. 2021). The results revealed that the distribution of households in the Swan River Basin had different variations in vulnerability depending on their exposure, sensitivity, and adaptive capacity.

Demographic elements, such as household and female population distributions, play a vital role in flood risk vulnerability in the study area. Where there is a high concentration of households, the female population shows

higher flood risk vulnerability, whereas households and female populations are sparse and show lower flood risk vulnerability.

In this study, we examined the relationship between flooded regions and the population residing there. Flood data show that heavy precipitation, inundated areas, and flooding increase the toll on human deaths. The inundation area had a significant impact on the population decline. The northern valley of the Swan River is sparsely populated because of the recurring floods. The number of deaths caused by flooding in a given year also led to population decline in the flooding area.



Conclusion

This study is based on GIS, and a spatial technique is used to analyze and understand flood vulnerability in the Una District of Himachal Pradesh. Flood-affected areas of different magnitudes were identified and mapped using arc GIS software. At the village level, the flooded area ranged from 0.003 km² to 1.83 km². Lawana Majra experienced the highest inundation, covering a total area of 1.8378 km². The analysis is useful for the local planning authority to identify risk areas and make appropriate decisions at the right moment. Flood vulnerability maps provide insights into emergency services and are valuable tools for assessing flood risk. Most of the population distribution was found in villages in the middle and lower basins of the valley, which are responsible for more flood vulnerability risk than villages in the upper basin of the Swan Valley.

The present analysis revealed that flood impacts were different for males and females, and that females were more vulnerable. In the study area, females distributed in the villages of the middle and lower basins of the valley were also responsible for higher flood vulnerability risk than the female population in villages in the upper basin of the Swan Valley. The female population shows a higher flood risk vulnerability when there is a high concentration of households. Demographic elements, such as household and female population distributions, play vital roles in flood risk vulnerability in the study area. Where there is a high concentration of households, the female population shows higher flood risk vulnerability, whereas households and female populations are sparse and show lower flood risk vulnerability.

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Nil.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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