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Flood-Affected Area Estimation through Remote Sensing and GIS: A Case Study of Fatehabad District, Haryana

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Abstract:
Floods are the most frequent and economically damaging natural disasters globally, causing significant loss of life and financial instability. They occur when water overflows its usual confines, such as rivers breaching their banks, often with little warning. If a community's ability to manage floods is overwhelmed, they turn into disasters. Research by Prakash Tripathi has been vital in understanding global flood impacts, using CRED's criteria for defining disasters. Floods impose heavier economic burdens and cause more deaths than any other natural disaster, with impacts often lasting years. Assessing the true cost is challenging due to inadequate measurement methods. Aid often falls short, exacerbating economic burdens locally and nationally.
Efforts to manage floods in India have included various governmental initiatives, but these have often been short-term and heavily reliant on structural measures. Mohit Prakash suggests a more rational approach, involving stakeholder participation for better flood management policies. In regions like Fatehabad, Haryana, floods are an annual occurrence, particularly severe in September. Satellite remote sensing has been used for flood monitoring and management, providing valuable data for planning and response.
A study from July 21 to August 15, 2023, used satellite data to monitor flood-affected areas, highlighting the extensive impact on land. Traditional methods for mapping inundated areas are time-consuming and expensive, but satellite data offers a more efficient solution. This data is crucial for flood fighting, control planning, and management.
Key Words: *Flood, Remote Sensing, GIS, Estimation, Affected Area.*

I. Introduction:

Floods rank as the most frequent and economically damaging natural calamities globally, inflicting profound devastation on both human lives and financial stability. They are characterized by the overflow of water beyond its usual confines, such as rivers breaching their banks and inundating adjacent dry areas, a phenomenon defined as "high-water stages." Despite often being local and short-lived events, floods typically occur with minimal advance warning. However, when the challenges posed by floods surpass the resilience of affected communities to effectively manage them, they escalate into full-fledged disasters. The analysis of disaster occurrences across different nations, conducted by (Prakash Tripathi-2015), has been instrumental in providing insights into this phenomenon. Data derived from this analysis has been published to inform further research and policymaking. The criteria outlined by the Centre for Research on the Epidemiology of Disasters (CRED) serve as foundational guidelines for defining disasters.

Floods, due to their recurrent nature, impose a heavier economic burden and inflict more significant loss of life than any other natural disaster. The impacts of floods often endure for several years following their onset. However, the absence of effective methods for accurately measuring post-flood impacts frequently results in assessments that underestimate both the extent of losses and damages, falling far short of actual costs.

Compensation and aid provided by governmental and non-governmental organizations often fail to cover the full extent of damages, thus exacerbating the economic burden on those affected by floods. This negative impact on economic growth is not confined to the local level but extends to the national economy as well. While controlling floods presents significant challenges, efforts to reduce vulnerability can be enhanced through the adoption of specific pre- and post-disaster measures. The occurrence of floods in Fatehabad in the Haryana regions has been studied extensively by (Surjit Saini). These floods recur almost every year, albeit with

variations in their extent and severity. Notably, the floods in September pose particular challenges. India floods (1993), DHA-Geneva information report, no. 223.

IPCC, (2007), Climate change, synthesis report An assessment of the intergovernmental panel on climate change, IPCC secretariat, World meteorological organization, Geneva, Switzerland. The flood situation in India presents a multifaceted challenge, rendering flood management a complex and arduous undertaking. Since independence, the Government of India (GoI) has undertaken a multitude of initiatives aimed at mitigating the occurrence and consequences of floods. This includes the establishment of various committees, task forces, and working groups, as well as the formulation of policies guiding water resource management, including flood management.

According to Mohit Prakash (2020), these strategies have predominantly adopted a normative approach, prioritizing the reduction of flood impacts through the implementation of structural measures and emergency responses. However, they have often been characterized by short-term objectives and a heavy reliance on a limited range of structural interventions. Consequently, the flood management framework has lacked the adaptability necessary to effectively address evolving challenges.

To overcome these deficiencies, emphasizes the importance of a more rational approach to flood management in India, one that incorporates stakeholder participation. By involving stakeholders from various sectors and communities in decision-making processes, policies and strategies can be devised that are more attuned to local needs and conditions. This would facilitate the development of a flood management system that is not only more effective but also better equipped to respond to changes over time. A high water level that floods the natural banks along part of a stream is called a high tide. Therefore,

A high water level that inundates the natural banks alongside a portion of a stream is termed a high tide, thus associating floods predominantly with streams or rivers. When the flow of a river surpasses the capacity of its bed, it enters a state of flood, causing excess water to overflow its banks and inundate adjacent dry land. In such instances, the channel and floodplain serve as conduits for the flowing water.

Floods and droughts present cumulative risks, although the Indian monsoon's unique characteristics mean that different parts of the country can experience these phenomena simultaneously. This seasonal nature of floods, occasionally compounded by flash floods, underscores the varied impacts of flooding across regions.

II. Methodology:

Satellite image- Sentinel-2A is a satellite part of the European Space Agency's Copernicus program, aimed at providing Earth observation data for various applications, including agriculture, forestry, land use, and emergency management. Here are some key details about Sentinel-2A:

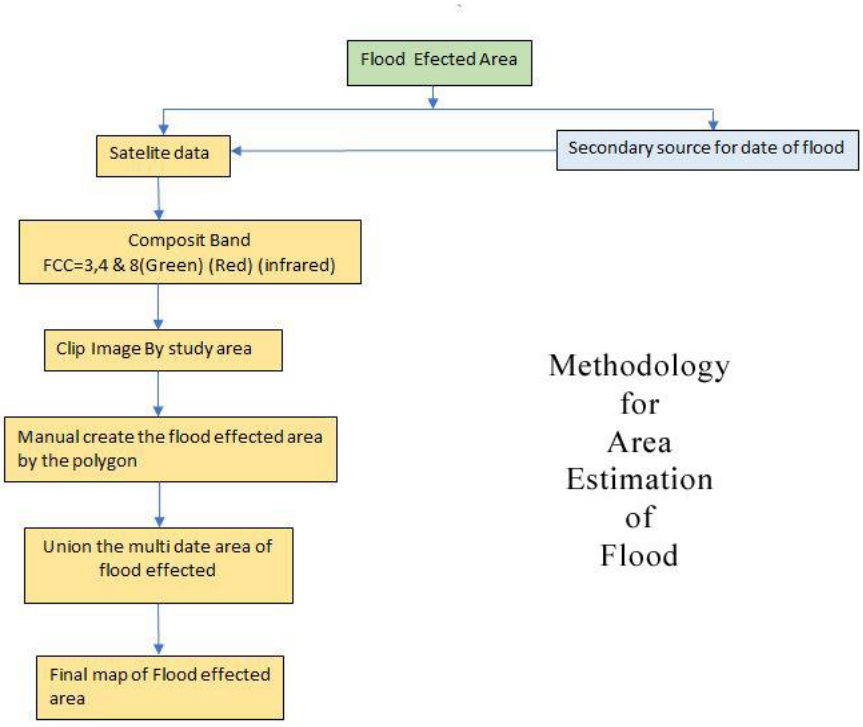


Figure: Flow chart of Methodology using in estimation of Flood Affected Area.

Sr. No	Band No	Band Name	Wavelength
1	Band 1	Coastal aerosol	443 nm
2	Band 2	Blue	490 nm
3	Band 3	Green	560 nm
4	Band 4	Red	665 nm
5	Band 5	RED edge	705 nm
6	Band 6	Red edge	740 nm
7	Band 7	Red edge	783 nm
8	Band 8	NIR	842 nm
9	Band 8a	NIR narrow	865nm
10	Band 9	Water vapor	945nm
11	Band 10	SWIR - Cirrus	1375nm
12	Band 11	SWIR	1610nm
13	Band 12	SWIR	2190 nm

Table-1: Detail of Bands of Sentinel-2 Satellite data.

FCC (False Colour Composite): In a typical FCC, the bands chosen for red, green, and channels are selected to highlight specific features

Administrative Boundaries – A critical component of efficient disaster management and response planning is estimating the area impacted by flooding within designated administrative Boundaries so use village and district boundary and the boundary take from survey of India in form shapefile. In order to precisely calculate and analyze the affected regions, this approach involves superimposing flood extent data onto administrative maps using Geographic Information System (GIS) techniques.

Image Processing: For the Land Use and Cover Mapping of 2023, the process begins by adding an image taken during the flood on 21st July 2023. A composite band is then created for detailed analysis. Next, the boundary of Fatehabad is added, and the images are clipped to focus on this specific area. Digital image processing techniques are applied to enhance image quality and extract meaningful information. Finally, a land use and cover map for 2023 is generated, incorporating an additional image captured after the flood on 15th August 2023.

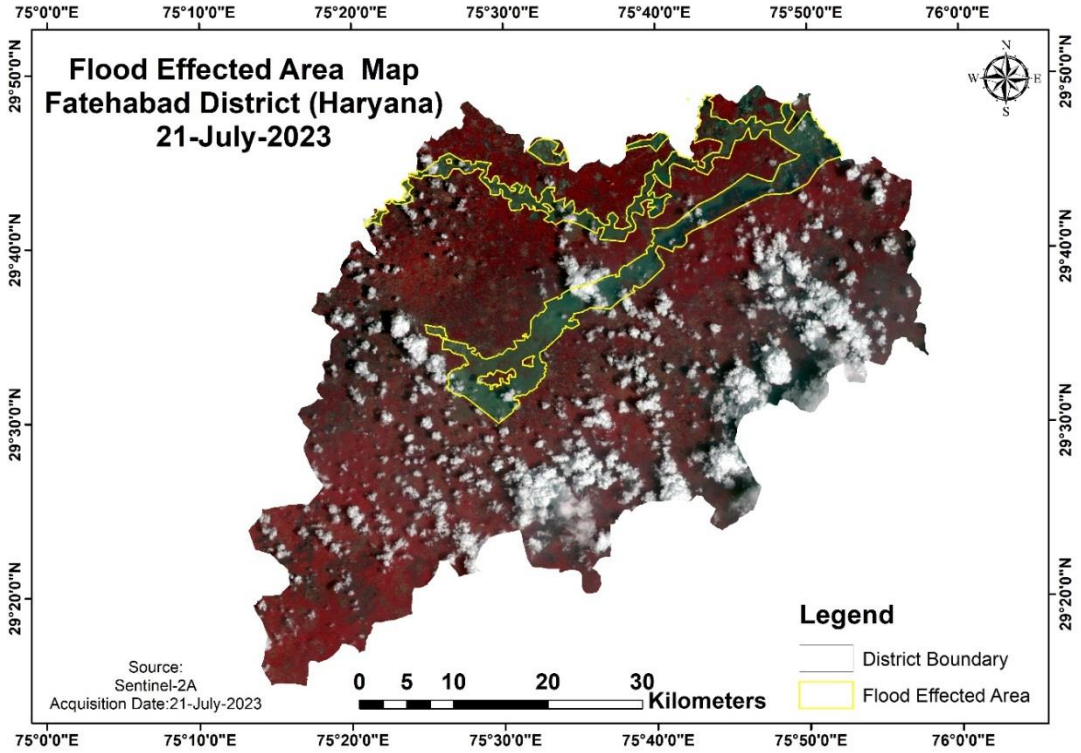
Observation of the Earth's surface is frequently conducted through satellite remote sensing. From July 21, 2023, to August 15, 2023, satellite data were used to monitor the study area. This enabled coverage of flood-inundated areas before, during, and after a flood event, facilitating flood inundation mapping and monitoring. The information generated is valuable for flood fighting, flood control planning, flood management, and floodplain zoning. Traditional techniques for delineating flood-inundated areas are difficult, costly, and time-consuming. Accessing inundated areas can be challenging, and it may not be feasible to map the entire affected area due to accessibility issues and the extended time required for conventional surveys. For real-time applications, satellite data can be obtained through priority services from data-providing agencies.

Image Classification Manual method have been applied to Image classification. In manual classification, analysts visually inspect images and manually delineate classes based on their expertise and interpretation of spectral and spatial characteristics. This method is labor-intensive and relies heavily on the skill and experience of the interpreter.

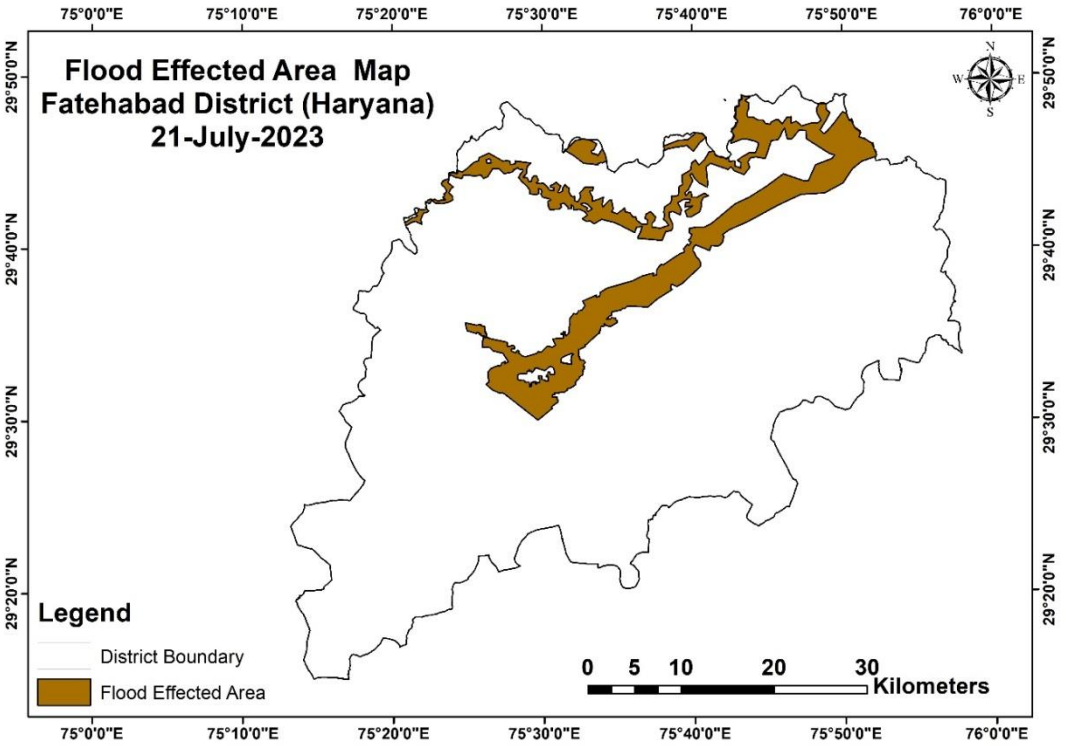
For inundation mapping, both visual interpretation and digital image processing techniques are utilized. In visual interpretation, elements such as color/tone, texture, size, pattern, association, and shape are used to identify objects and delineate flood-inundated areas. A photo interpretation key is prepared, listing these elements for various objects. False color composites (FCC) or near-infrared images can be used for interpretation, although cloud shadows are difficult to distinguish from clear water areas, and flooded areas may not be easily differentiated from urban areas.

III. Result and Discussion:

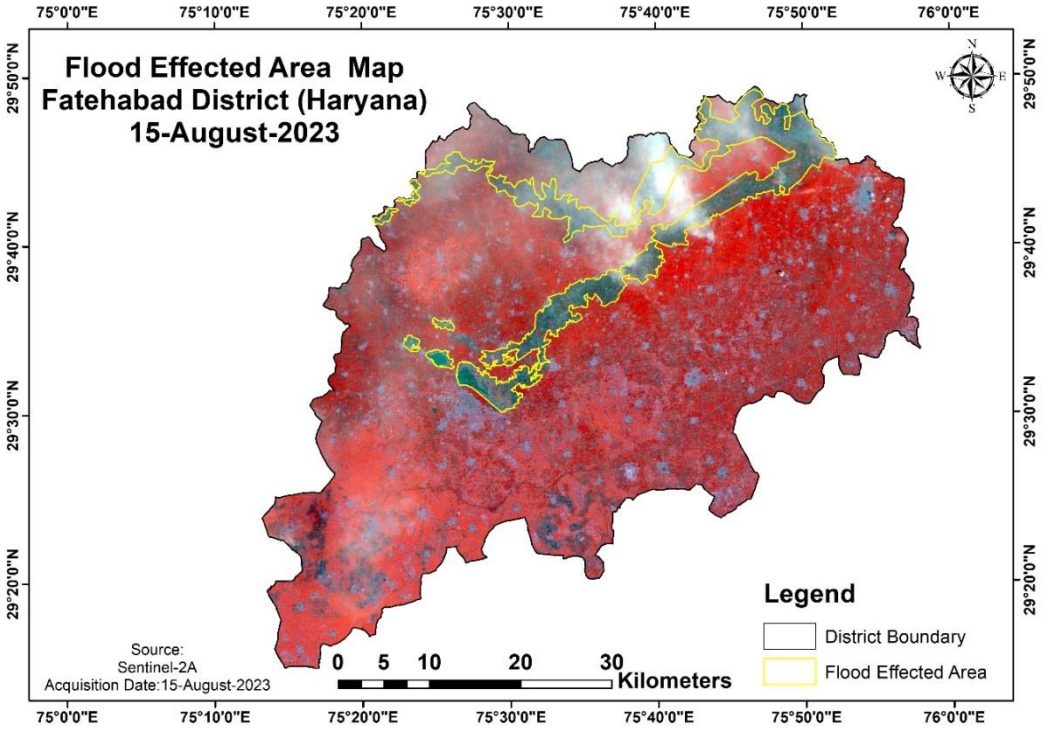
A study conducted from July 21 to August 15, 2023, utilized satellite data to monitor flood-affected areas, highlighting the extensive impact on land. Traditional methods for mapping inundated areas are time-consuming and expensive, but satellite data offers a more efficient solution. The satellite data revealed significant inundation across the region, confirming the extent of the flood's impact. This information is crucial for flood fighting, control planning, and management, offering a rapid and cost-effective means to assess and respond to flooding.



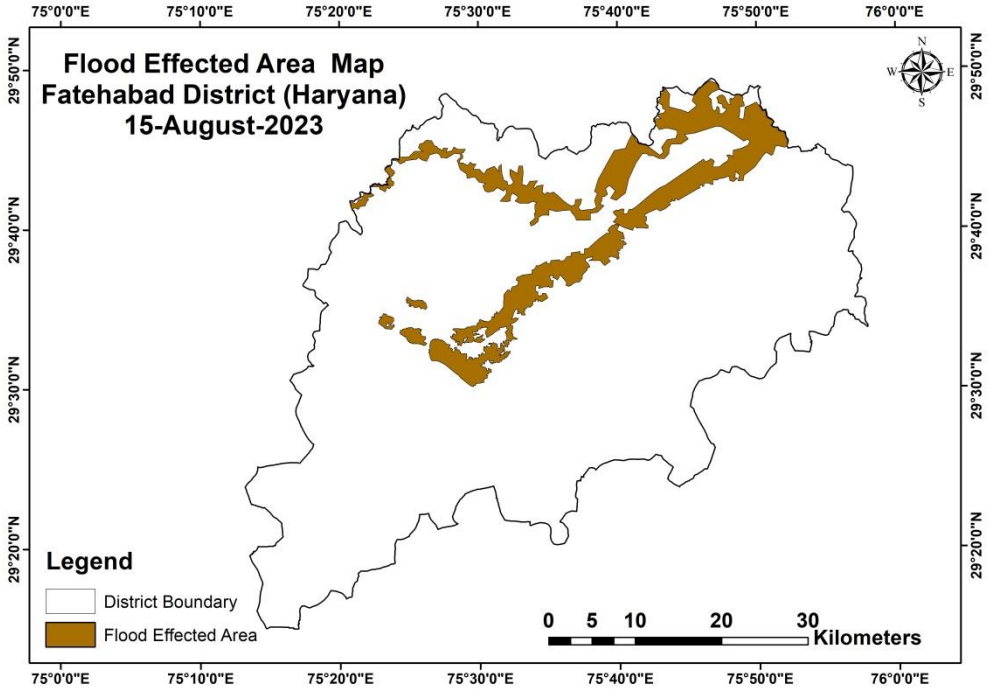
Map-1: Flood Effected area map of fatehabad District (21- July-2023) with Satellite Image.



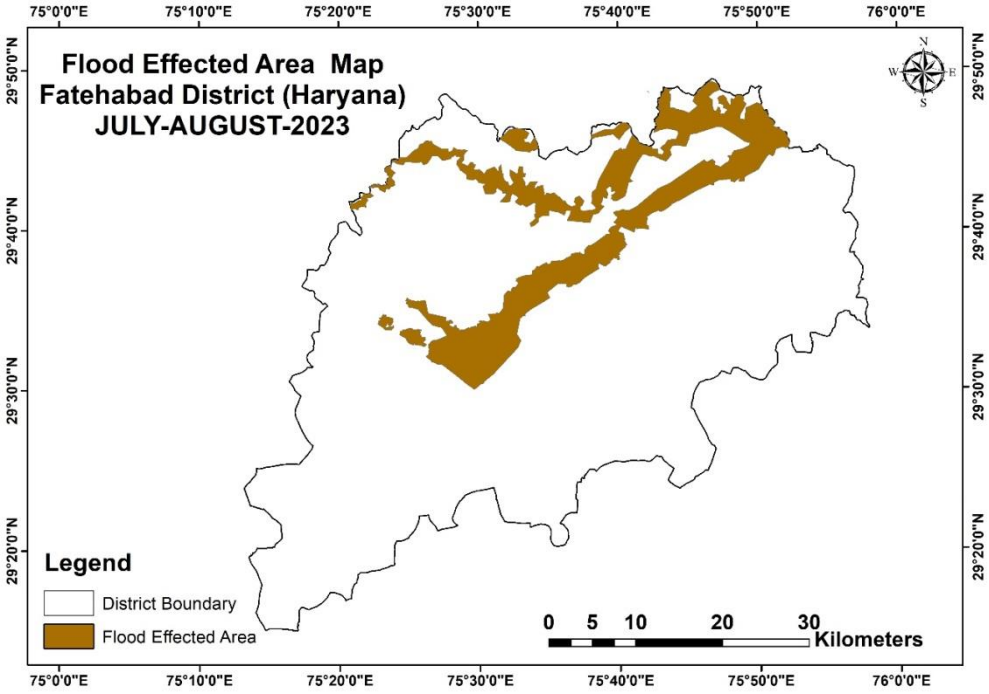
Map-2: Flood Effected area map of fatehabad District (21- July-2023).



Map-3: Flood Effected area map of fatehabad District (15- August-2023) with Satellite Image.



Map-4: Flood Effected area map of fatehabad District (15- August-2023).



Map-5: Total Flood Effected area map of Fatehabad District.

Sr. No	Flood Month	Flood Effected Area (in hectare)
1	July (21-07-2023)	25745.2
2	Augyust (15-08-2023)	25083.6
3	July-August	30892.4

Table-2: Flood Affected area of Fatehabad District

This table indicates that on the 21st of July, 2023, a significant flood event impacted a total of 25,745.2 hectares of land. This data point suggests the severity and extent of flooding on that particular day, which can be used for analysis of flood patterns, disaster response planning, and resource allocation.
This indicates that on the 15th of August, 2023, a flood event impacted a total of 25,083.6 hectares of land. This data point, along with the previous one for July, can help in understanding the extent of flood damage over consecutive months in 2023, aiding in trend analysis and disaster management planning.

Tehsil	Village	Tehsil	Village
Fatehabad	Ayalki	Ratia	Mirana
Fatehabad	Basin	Ratia	Muhammadki
Fatehabad	Bhirarana	Ratia	Muhammadpur Sotar
Fatehabad	Bhutan Kalan	Ratia	Nangal Dhani
Fatehabad	Bisla	Ratia	Nathwan
Fatehabad	Boswal	Ratia	Palsar
Fatehabad	Dhani Thoba	Ratia	Pilchian
Fatehabad	Dher Jafarwal	Ratia	Ratangarh
Fatehabad	Fatehabad I	Ratia	Ratia
Fatehabad	Fatehabad Ii	Ratia	Rojhanwali
Fatehabad	Hijraon Kalan	Ratia	Sardariwala
Fatehabad	Hijraon Khurd	Ratia	Shahnal
Fatehabad	Katankheri	Ratia	Shahzadpur
Fatehabad	Khan Mohammad	Ratia	Shekhupur Sotar
Fatehabad	Khanpur	Ratia	Sukhmanpur
Fatehabad	Khobar	Ratia	Teliwara
Fatehabad	Majra	Tohana	Budhanpur
Fatehabad	Mallhar	Tohana	Chandpura (Bhawarthali)
Fatehabad	Razabad	Tohana	Chillewal
Ratia	Aharwan	Tohana	Chuharpur
Ratia	Alawalwas	Tohana	Dharsul Kalan
Ratia	Alika	Tohana	Dharsul Khurd
Ratia	Babbanpur	Tohana	Dher
Ratia	Badalgarh	Tohana	Diwana
Ratia	Bahmanwala	Tohana	Girnun
Ratia	Baliyala	Tohana	Haidarwala
Ratia	Bhawanikhera	Tohana	Handalwala
Ratia	Birabadhi	Tohana	Himmatpur
Ratia	Bora	Tohana	Jakhal Mandi
Ratia	Chandoh Kalan	Tohana	Jamalpur Shaikhan
Ratia	Chandoh Khurd	Tohana	Kanakhera
Ratia	Chimun	Tohana	Karandi
Ratia	Dhani Raipur	Tohana	Kudni
Ratia	Gandha	Tohana	Lalluwal

Ratia	Ghaswa	Tohana	Mamunpur
Ratia	Gurusar	Tohana	Mandhalian
Ratia	Hamzapur	Tohana	Meond Begumwali
Ratia	Hasanga	Tohana	Meond Boghanwali
Ratia	Kalandargarh	Tohana	Musakhera
Ratia	Kalotha	Tohana	Nanheri Kalan
Ratia	Kamana	Tohana	Narei
Ratia	Kanwalgarh	Tohana	Nathuwal
Ratia	Khai	Tohana	Puro Majra
Ratia	Khairpur	Tohana	Rattatheh
Ratia	Kunal	Tohana	Rayanwala
Ratia	Ladhera	Tohana	Rupanwali
Ratia	Lali	Tohana	Sadhanwas
Ratia	Lambha	Tohana	Shakarpura
Ratia	Madh	Tohana	Sidhani
Ratia	Madhawali	Tohana	Talwara
Ratia	Mahamra	Tohana	Talwari
Ratia	Malwala	Tohana	Udepur

Table-3: List of Flood Affected village of Fatehabad District .

Combined July-August: The total affected area for the floods during both July and August is 30,892.4 hectares. This suggests that there might be overlapping areas affected by floods in both months and additional areas affected in July-August that are not covered individually.

IV. Conclusion:

In conclusion, floods are the most frequent and economically devastating natural calamities globally, inflicting significant damage on human lives and financial stability. They occur when water overflows its usual confines, such as rivers breaching their banks and inundating adjacent dry areas, often with little warning.

The occurrence of floods in Fatehabad, Haryana, has been extensively studied, particularly by Surjit Saini. These floods recur almost every year, with varying extents and severity, notably in September. A study conducted from July 21 to August 15, 2023, used satellite data to monitor flood-affected areas. This approach demonstrated the extensive impact on land and highlighted the efficiency of satellite remote sensing in flood monitoring and management. Traditional methods for mapping inundated areas are time-consuming and expensive, but satellite data offers a more efficient and accurate solution. This data is crucial for flood fighting, control planning, and management.

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