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# Development of a Model to Assess Flood Affected Areas in Near Real Time along Major Rivers of Uttar Pradesh, India

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**ABSTRACT**: Remote Sensing and GIS is well-knowntechnology for establishment of flood inundation model for planners and decision makers for flood management. Generally, flood is submerging of water in a normally dry area. There are many factors responsible for flood such as rainstorms, slow water run-off, intensity of rainfall, duration of rainfall, catchment size, earthquakes, broken dams etc. Uttar Pradesh is one of the states which facing flood problem every year because of over flow of waterin rivers flowing through the state as Ganga, Yamuna, Ramganga, Gomti, Ghaghra, Sharda, Rapti, BhuriRapti etc. In 2013, 64 districts of Uttar Pradesh wereadversely affected by flood. Large area of agriculture land, population and household were affected by flood and waterlogging every year. The present study indicates the significance of Remote Sensing and GIS for developing a flood inundation model to assess the flood affected areas and numbers of flood inundated villages in each district in almost real time. The present study is an attempt to take decision in near real-time on flood management for planners and decision makers using microwave remote sensing satellite data (RADARSAT and RISAT). The model generates statistics of flood affected areas near or in the village, affected blocks and districts within two hours after receiving flood layers from National Remote Sensing Center (NRSC), Disaster Management Division, Hyderabad. On the basis of this model the relief and rescue operation may be planned in more effective manner and saving human lives and livestock.

KEYWORDS: Flood, Flood inundation model, Rainfall, Remote Sensing, Microwave Remote Sensing and GIS.

### I. INTRODUCTION

Floods have been a recurrent phenomenon in India and cause huge losses to lives, properties, livelihood systems, infrastructure and public utilities. Floods mostly occur in the country during south west monsoon period spreading from June to September, though cyclonic storms are common during October to December. According to National Disaster Management Authority, India's high risk and vulnerability is highlighted by the fact that 40 million hectares out of a geographical area of 3,290 lakh hectares is flood prone area. On an average every year, 75 lakh hectares of land is affected, 1600 lives are lost and the damage caused to crops, houses and public utilities is Rs. 1805 crores due to floods. The Ganga Plain is one of the most densely populated regions of the world due to its fertile soil and availability of water. Alluvial plain of rivers are the lifeline for millions of people. Unplanned expansion has enhanced the damage due to flooding during high-discharge period and lateral erosion during low-discharge period (Singh and Awasthi, 2010). The incidence of flooding is frequent in eastern Uttar Pradesh, which is broadly the result of spilling of rivers



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such as Kuwana, Rapti, Chhoti Gandak, Ghaghara, and Great Gandak. The flooding events badly affect the human life and livestock (Singh, 2007).

### II. RELATED WORK

Remote sensing technology along with geographic information system (GIS) hasbecome the key tool for flood monitoring and modelling in recent years. Both optical and microwave remote sensing provide all weather data for flood. Microwave remote sensing provides all weather capability compared to the optical sensors for the purpose of flood mapping. It is evident that GIS has a great role to play innatural hazard management because natural hazards are multi-dimensional and the spatial component is inherent (Coppock, 1995). Smith (1997) reviews the application of remote sensing for detecting river inundation, stage and discharge. Since then, the focus in this direction is shiftingfrom flood boundary delineation to risk and damage assessment.

According to Brackenridge and Anderson (2006); data in optical wave length however, is unable to penetrate cloud, which puts limitations on its daily use. This has prompted the use of data of longerwavelength, such as microwave data, as these are virtually all-weather, able to penetrate cloud (Brakenridge *et. al.*, 2007; Bartsch *et al.*, 2008; Ticehurst *et. al.*, 2009a). SyntheticAperture Radar sensors have proven useful in mapping floods (Alsdorf *et. al.*, 2007), but they are not routinely available atregional scales. Passive microwave sensors, however, acquire data at a high temporal frequency (1-2 times daily) on a near global scale.

Ramalingam and Vadivukarasi, (2005) has used SAR data for flood inundation studies. Two hours of rain in November 2002 was enough to create total chaos in several parts of the city and its outskirts. The study area comprises of Velachery and its surrounding. They used data such as RADARSAT SAR - November 2002, IRS LISS III and PAN merged imagery-2002, Maps of Adyar and miscellaneous watersheds (4C2C2), Survey of India Toposheets, Rainfall level data – November 2002.

Kumar, A (2005) has applied GIS techniques in Flood Hazard Management in North Indian Plain. This system constitutes of the Ganga, and its largest tributary the Yamuna, other Himalayan rivers- Ramganga, Gomati, Ghaghara, Gandak, Rapti, Gandak and Kosi, and some peninsular rivers, like Chambal, Son and Punpun. This system is also examines the potential of GIS to meet the purpose.

Chandran *et.al*, (2006), has used the Airborne Synthetic Aperture Radar (ASAR) images in mapping the flood inundation and causative factors of flood in the lower reaches of Baghmati river basin for the period July– October 2004. Integration of the flood inundation layer and land cover layer derived from LISS III data indicate that 62 percent of the agricultural area was inundated. Floodwater drained faster in the left bank, whereas it was slow in the right bank. The Digital Elevation Model of the area shows that the flood-prone right bank of the Baghmati River is a topographic low sandwiched between Kosi and BurhiGandak highs (mega fans). Area under flood inundation for various land cover classes has been shown comparative bar graph. Spatial maps such as fluvial geomorphology of the study area, drainage configuration of Baghmati river during pre-flood, flood and post-flood, Transverse spatial profiles across Kosi–Ganga transect, Bhirkhi–Ranka transect and Bharath– Bachhauta transect and, Longitudinal spatial profiles along (a) Chanhanadi and (b) under fit channel of Baghmati, and difference image (pre-post) showing flooding from tributaries and embankment failure has been prepared by them. In this study, they observed that the right bank of the Baghmati river undergoes frequent flooding due to topography, channel morphometry and discharge characters. The embankment constructed along the course (Baghmati and BurhiGantak) is found to impede therecession of floodwater.

Therefore, it is mandatory to build up a strategy for minimizing the flood risk and develop a model for indication of flood prone areas in a district. The present study is an attempt to describe the complete scenario of flood in Uttar Pradesh and develop a flood inundation model for Uttar Pradesh state using microwave remote sensing and GIS.



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#### III. STUDY AREA

Uttar Pradesh is one of the most flood-affected states in India among the Bihar, West Bengal, Assam, and Orissa. Uttar Pradesh has experienced massive flooding in 1998, 2000, 2001, and 2008. It is estimated that 30 districts of this state are seriously flood prone area. The Uttar Pradesh covers an area of 292183 ha. The state is blessed with various rivers such as Ganga, Yamuna, Ramganga, Gomti, Ghaghra, Sharda, Rapti, BhuriRaptietc, (Figure1)but unfortunately these rivers are also become curse in the condition of flood. In this study, 5 km buffer along major rivers covering an area of 23000 sq km (approx) were taken up for detailed study to address the problem of flood. The flood is a recurring phenomenon along these rivers and was observed to be more significance in September to October every year. The study also includes the assessment of flood in terms of area and number of villages inundated.





Fig-1: Showing the study area: Ganga Basin (Source: www.mapsofindia.com)

### IV. DATA USED

The following data used is for present study:

- 1. LISS -III Satellite Data used for detailed mapping of Rivers
- 2. Flood Layer from RADARSAT or RISAT Satellite Data of various dates of 2012-2014were used for flood inundation mapping. RISAT data (Flood Layer) of study area collected from NRSC Disaster ManagementDivision, NDC Hyderabad of during flood (July-Sep) every year since 2008.)
- 3. Base layers, consisting administrative boundary as district, block and village boundary were used from Remote Sensing Applications Centre, Uttar Pradesh

### V. METHODOLOGY

A complete database is necessary for developing a working model. Database should be well defined and all useful information should be there. Number of Attribute, name, type and length should be predefined (Table 1 and 2) Because all the analysis performed on the basis of database, so the database should be clear and without any error. In this study the generated database is error free and revival. The first step in creating database is integration of allbasis information about administrative boundary as block name, district name and village falling under river's 5 km. buffer. After creating well organized and error free database next process is developing model for estimation of flood affected areas (Figure 2).



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Fig-2: Flow chart of Working Methodology for preparation of Model

Note:

1= Flood and waterlogged affected areas And 0= Non affected areas



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Some example for generation of queries Select from attribute

- 1. *"Status=1"* (Flood and waterlogged affected villages in Uttar Pradesh)
- 2. *"Status=1 and Ganga=1"* (Flood and waterlogged affected areas in 5 km. buffer of Ganga River) To find flood and waterlogged affected areas along other River change the river name in query box
- 3. "*Status=1 and Affected\_area>5Ha*." (More than 5 ha. flood affected areas of a village in Uttar Pradesh (area can be changed according to requirement)
- 4. *"Status=1 and Vill\_Type= Rural or Town"* Flood affected Settlements in Uttar Pradesh and(Rural or Town)
- 5. Queries according to need



**Note:** For estimation of flood affected settlements replace village boundary layer with Settlement layer and for estimation of flood affected infrastructure replace village boundary layer with infrastructure layer. "The model will be also used for estimation of flood affected plots (numbers of farmers if available in attribute table) replacing the village boundary layer to plots layer"

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	Table1: Attr	ibute Scheme for preparation of Database	
S.N.	Attribute_name	Attribute_Type	Length
1	ID	Integer	500
2	Shape	string	10
3	District	String	50
4	Block	String	50
5	Village	String	50
6	Village_Type	String	50
7	Status	Integer	5
8	Ganga	Integer	5
9	Yamuna	Integer	5
10	Ramganga	Integer	5
11	Sharda	Integer	5
12	Ghaghra	Integer	5
13	Rapti	Integer	5
14	Other Rivers	Integer	5
15	Area	Double	1000000
16	Affected Area	Double	1000000



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	Table2: Database Structure													
S.N	District	Block	Village	Village Type	Status	Ganga	Yamuna	Ramganga	Sharda	Ghaghra	Rapti	other	Area	Affected Area

#### VI. RESULTS AND DISCUSSIONS

On the Basis of above stated model the statics in different dates of years for any districts as well as for village has been estimated as follows:

- Flood and waterlogged affected areas nearby villages
- Flood and Waterlogged affected districts in Uttar Pradesh
- River wise flood and waterlogged affected areas nearby village
- Flood and waterlogged affected settlements
- Spatial extent of flood inundation
- Assessment of damage

To determine flood affected zones, the use of this model within geographic information system is very effective if only, the appropriate decision rules were defined. Therefore it is necessary to collect more much data with the help of satellite observation and ground truth survey. To demarcate flood affected zone are a period of time.

This model has been effectively used for estimation flood affected villages along Major rivers in Uttar Pradesh since 2012. The results shows that total flood affected villages in 2014 in Uttar Pradesh are2446, total affected settlements are 256 along Rapti and BurhiRapti River covering 6 district and total flood affected villages is 357, total affected settlements are 1745 along Ghaghra River covering 12 district in 2014 (Plate-1,2 & 3, Table-3 and Table-4) (Source: RSAC, UP, Technical Report).

For calculate flood affected areas with the help of model in 18<sup>th</sup>, 19<sup>th</sup> and 23<sup>rd</sup>& 24<sup>th</sup> Aug 2014. 18, 17 and 13 districts were affected by flood and waterlogging in Uttar Pradesh respectively in 18<sup>th</sup>, 19<sup>th</sup> and 23<sup>rd</sup>& 24<sup>th</sup> August 2014. In same date 123, 84 and 61 Blocks and 2445, 1998 and 1052 villages were affected by flood and waterlogging respectively (Plate-1, 2 & 3, Table-3 and Table-4).

This model can replace, supplement or complement the existing flood management system. Extensive use of this model have great prospect in creating database on flood proneness, risk assessment and relief management in near real time. Therefore the present study indicates the utilities of remote sensing and GIS for identification of affected Villages, settlements etc. by flood and waterlogging in near real-time. The relief and rescue operation may be planned in more effective manner to tackle a disaster and saving life of human beings.



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Plate-1: Flood affected areas as on 19th August 2014 calculated with the model (Source: http://rsacup.org.in/flood2014.html)



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Plate-2: Flood affected areas as on 23rd& 24th August 2014 calculated with the model (Source: http://rsacup.org.in/flood2014.html)





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Plate-3: Flood affected settlements as on 23rd& 24thAugust 2014 calculated by model Source:// http://rsacup.org.in/flood2014.html



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S N	District	18 <sup>TH</sup> A	AUG' 2014	19 <sup>th</sup> AUG'2014		23 <sup>th</sup> &24 <sup>th</sup> Aug	
5.1.1		Block	Village	Block	Village	Block	Village
1	Ambedkar Nagar	5	32	5	22		
2	Azamgarh	3	50	3	52	3	61
3	Bahraich	9	190	7	186	5	26
4	Ballia	11	102			7	54
5	Balrampur	2	32	8	388	8	310
6	Barabanki	4	125	4	128	4	58
7	Basti	6	83	7	130	4	30
8	Deoria	9	135			4	22
9	Faizabad	5	46	5	41	3	7
10	Gonda	4	46	3	56	3	32
11	Gorakhpur	15	324	13	213	13	399
12	Khushi Nagar	9	174				
13	MaharajGanj	11	255	3	25		
14	Mau	2	17	2	17	2	10
15	Shravasti	6	224	5	185	3	23
16	Sitapur	8	188	3	221	2	20
17	Lakhimpur- Khiri	4	31	3	35		
18	Siddharth Nagar	10	391	11	273		
19	St. Kabirnagar			2	26		
	Total	123	2445	84	1998	61	1052
	Souces: //http://rsacup.org.in/flood2014.html (Estimated by model)						



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		Flood and waterloaded	affected blocks-07
		Flood and waterlogged a	ffected villages=186
S.N.	District Name	Block Name	Village Name
1	BAHRAICH	Balaha	PurainaBhawaniBux
2			ShahpurKhurd
3			Balsinghpur
4			Nibiya Ray Bojha
5			Rajapur Kalan
6			Chandanpur
7			LakshmanpurMatehi
8			Hanspur
9			PakariyaDiwan
10			Shahpur Kalan
11			Sarramundari
12			Lagdiha
13			AmwaHusenpur
14			NausarGumariha
15			GularihaJagtapur
16			Ghurghutta
17			Kola Jhinsiya
18			Chiraiya
19			RajapurGirant
20			BhawaniyapurBanghusar
21			Maghi
22			Daulatpur
23			Baraiya Kalan
24			Baruha
25			Saraiyan
26			DaljitPurwa
27			Khairisamaisa
28			Vaibahi
29			Banjariya
30			Teri
31			Patrahiya
32			KakrahaBodhawa

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33		Kakri
34	Jarwal	Ahata
35		Bahrampur
36		TappeSipah
37	Kaisarganj	Kandauli
38		Badrauli
39		Godahiya No. 1To 4
40		Chulamma
41		Baghaiya
42		Nawgaeya
43		Danawal
44		Rewali
45		Sohras
46	Mahasi	Kewalpur
47		Badrka
48		Chkaiya
49		Bansgadhi
50		Bakaina
51		Bhawanipur
52		Dhanwa
53		Thailiya
54		GarethiGurudatta Sing
55		Bahduriya
56		Pachdevri
57		MaikuPurwa
58		Pipri Mohan
59		Pure Ganga Prasad
60		Pure Hindu Singh
61		Padohiya
62		Kotiya
63		Sigiyansirpur
64		Pure KuberPanday
65		Mahsi
66		AgrauraDubaha
67		Pure BastiGaderiya
68		Pure Deldar Singh
69		Pure Prasad Singh



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70		Pure Sita Ram
71		Nakawa
72		Belhaura
73		Pure Arjun Singh
74		Galkara
75		Sikandarpur
76		Aourahi
77		SisaiyaChuraman
78		Nathuwapur
79		HardiGaura
80		Bamabhauri
81		Ganga Purwa
82		Bhagwanpur
83		RewatiPurwa
84		RamawapurKhurd
85		Karehana
86		Airea
87		Murwa
88		Fate Purwa
89		BabhnautiSankarpur
90		Lodhauni
91		Kolyala
92		Gauriya
93		Pipra
94		Kayampur
95		BadwaBehra
96	Mihinpurwa	Dharmpur/Murtiha
97		Sujauli
98		NishanGara Range
99		Harkhapur
100		Chakiya/Rupaidiha
101		Kathoutiya
102		SemariGhatahi
103		Bojhiya
104		LalpurChandaJhar
105		Sarra Kalan
106		Mahrajsingh Nagar



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107		Amritpur
108		Puraina
109		GauraPipra
110		Dharmapur
111		Parariya
112		Kakraha Range
113		Madhawapur
114		BhiwrabirGhat
115		Songawa
116		Kharaiya
117		Raghawapur
118		Kanjarwa
119		Naubana
120		Urra
121		Gaurariya
122		MihiPurwa
123		Khariya
124		Semrahana
125		Majhara
126		Nainiha
127		Pairua
128		Gurh
129		Jhala
130		Girgtti
131		Katraniya
132		Petarha
133		Rajapur
134		Jalim Nagar
135		Mangauriya
136		SomaieGauri
137		Argorawa
138		BakhtawarGauri
139	Phakharpur	BabhnautiUrfShahar G
140		Baundi
141		Ratanpur
142		Tulapur
143		Silauta



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144		DhareharaNakdilpur
145		Atodar
146		Naubasta
147		Bhauri
148		Sipahiya Hulas
149		Nandwal
150		Samada
151		AllipurDarauna
152		MajharaTawkali
153	Shivpur	Rampur DhobiyaHar
154		Matiha
155		Newada Pure Kasbati
156		Vitaniha
157		Ray Ganj
158		Arnawa
159		Dallapurwa
160		Jarbadhiya
161		Yakghara
162		Pipriya
163		Khaira Kalan
164		Sohbatiya
165		Saiyad Nagar
166		Sankalpa
167		Bahorikapur
168		Basantapur
169		Baundi
170		ValduPurwa
171		Bardaha
172		ChauksaHar
173		Girda
174		Laukiha
175		Pathak Purwa
176		Sheopur
177		Tigra
178		GujratiPurwa
179		BelaMakan
180		Rakhauna



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181		Ambarpurwa
182		Baruhi
183		Behra
184		MajhaDariyaKhurd
185		Dhakiya
186		Narotampur

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