Bihar Floods: September-October 2019

Delayed and unusual south west monsoon

This year, the South West Monsoon arrived in Kerala on June 8th, seven days later than the normal onset date in Kerala, and started its withdrawal from North-West India on 9th October, against the normal withdrawal around 1st September, making it one of the most delayed withdrawal in recorded history[1]. The SWM 2019, despite its delay in onset and withdrawal, delivered one of the highest experienced rainfall over the past 25 years, recording 968.3 mm against the long period average of 880.6 mm with a deviation of +10%. The unusual SWM has resulted in severe damaging floods and associated infrastructure damages across several parts of the country. The worst flood affected states in SWM 2019 are Assam, **Bihar**, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Punjab and Uttar Pradesh.

Bihar floods 2019

In Bihar, the onset of SWM was observed on 21st of June and it experienced its first floods in the second week of July when 18 districts were inundated. The rains and ensuing floods continued battering Bihar in the month of August resulting in floods in part of the state (14 districts). Incessant rainfall in Bihar and Uttar Pradesh along with the release of water from barrages further resulted in flooding in parts of the state, in the month of September, the third consecutive month. The devastating flood event in September month started during the last week and the flood/water-logging conditions persisted till the first week of October.

The state government has kick-started the process of assessing the damages and losses due to the deluge. In order to assist the state and other stakeholders, RMSI has carried out a preliminary damage assessment over the state resulting from the flood event (during the last week of September extending till October 2nd). Sentinel-1 satellite data (SAR imagery) provided by the European Space Agency for the dates 27 September, 30 September and 2 October were analyzed to extract the inundation area over the state. The resulting assessment of preliminary damages in Bihar is described in this report.

Table 1: Preliminary damage report - important districts

Inundation	Key districts affected
Built up-area	Khagaria, Munger, Darbhanga, Lakhisarai, Begusarai, Patna, Jehanabad, Siwan and Bhagalpur
National highways	Patna, Bhagalpur, Saran, Begusarai, Khagaria, Bhojpur and Jehanabad
Local roads	Darbhanga, Nalanda, Katihar, Madhubani, Samastipur and Lakhisarai
Crop area	Khagaria, Lakhisarai, Bhagalpur, Munger and Darbhanga

[1] The most delayed SWM withdrawal in the past years has been recorded in 1961 (October 1st) followed by 2007 (September 30th)

The following maps summarize the estimated flood depths and affected pincodes:

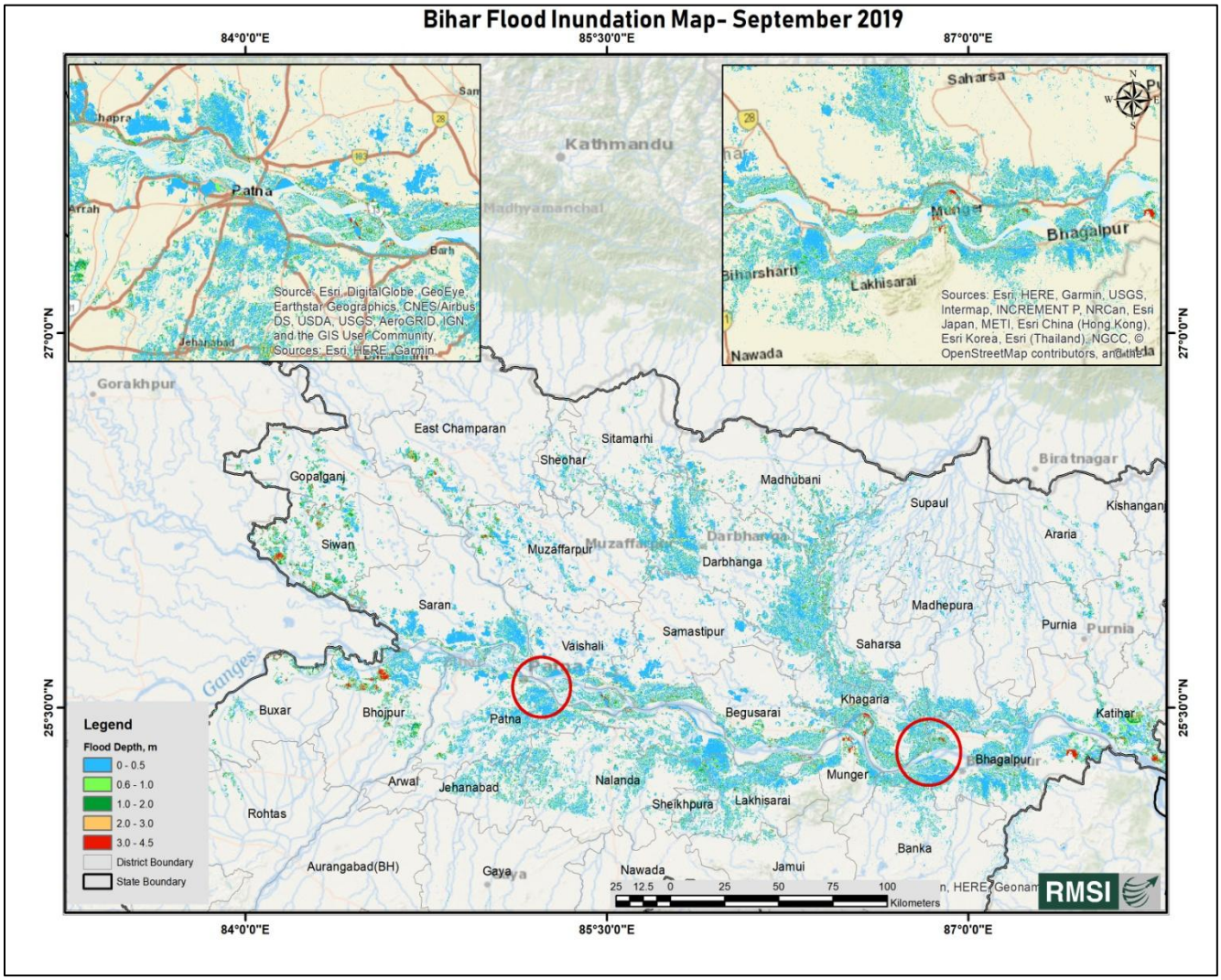

Figure 1: Bihar Flood Inundation Map- September 2019

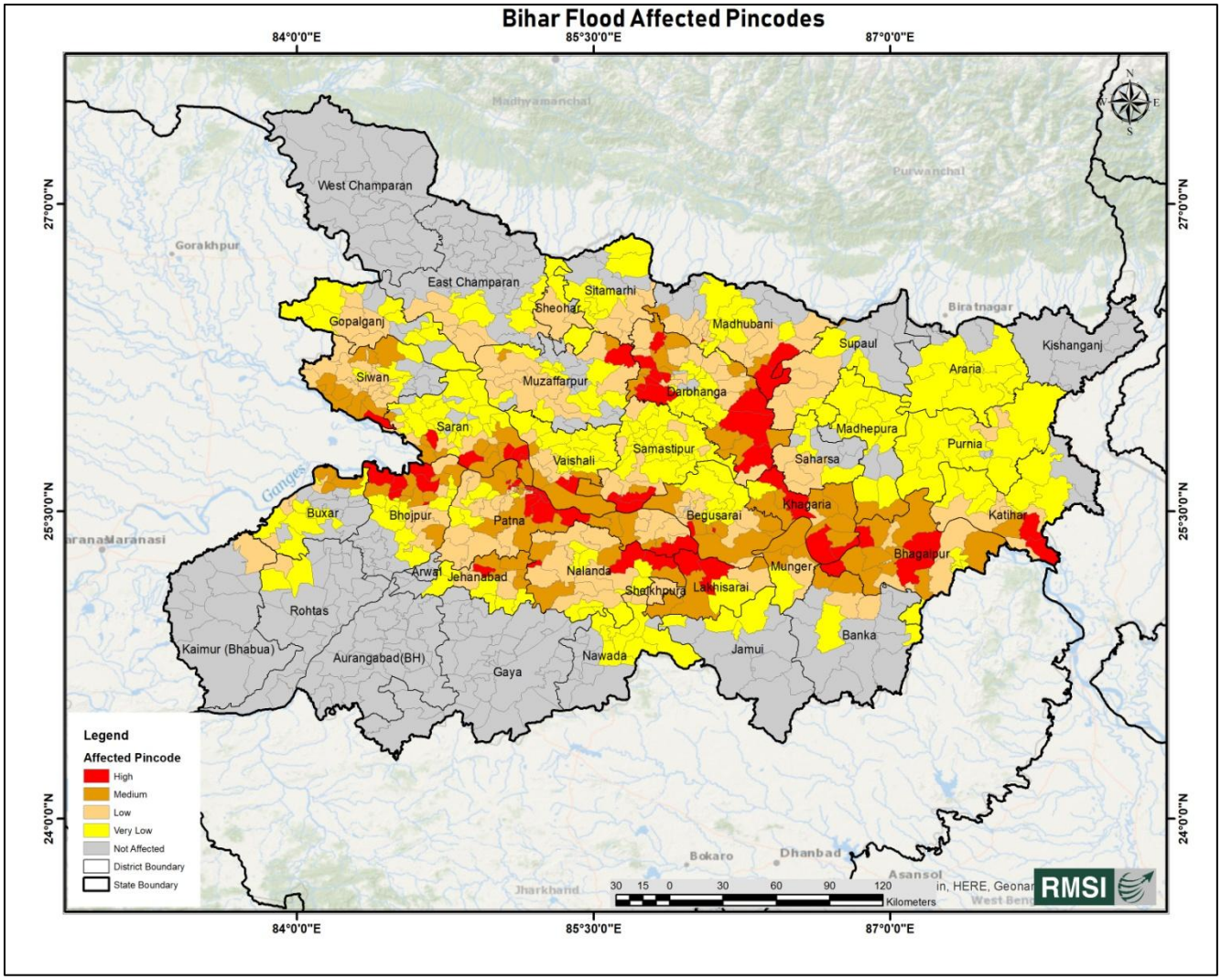

Figure 2: Bihar Flood Affected Pincodes

Likely causes

Between 26th September and 2nd October, Bihar and Uttar Pradesh witnessed widespread heavy rainfall with 37 and 56 districts respectively in the states recording large excess rainfall (as compared to the normal rainfall for the mentioned period). According to the weather department, Patna (the state capital of Bihar) received more than 200 mm of rainfall on 28th September and Principal Secretary of Disaster Management Department described it as "*totally unexpected*". The percentage rainfall deviation against the normally observed rainfall for Bihar and Uttar Pradesh between 26th September and 2nd October is shown in the following images:

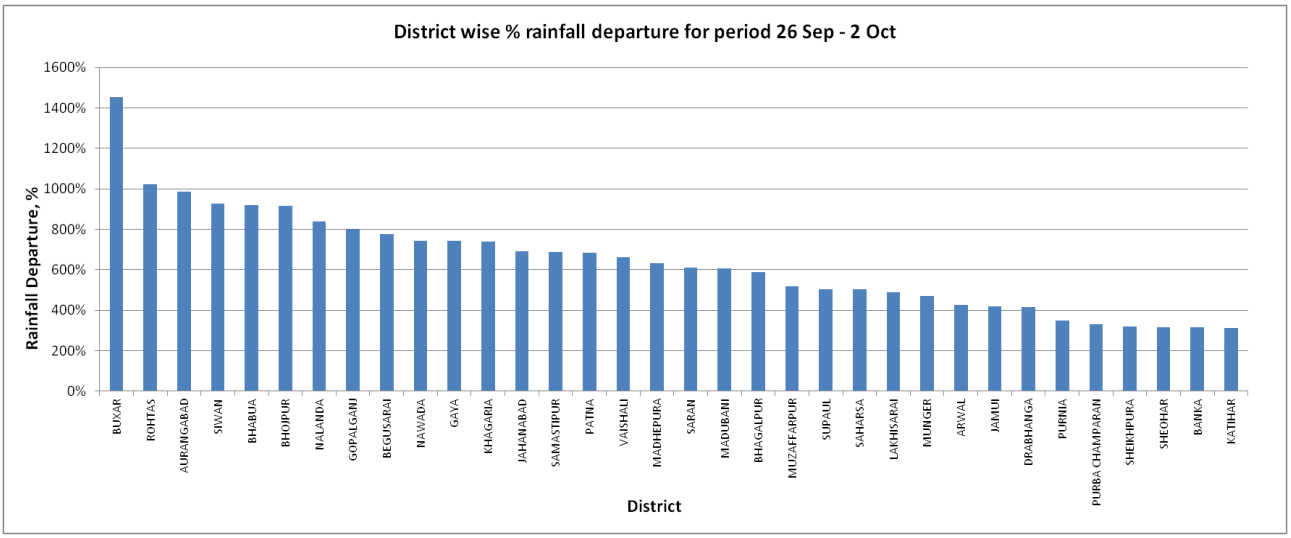

Figure 3: District wise % rainfall departure - Bihar - 26th September to 2nd October

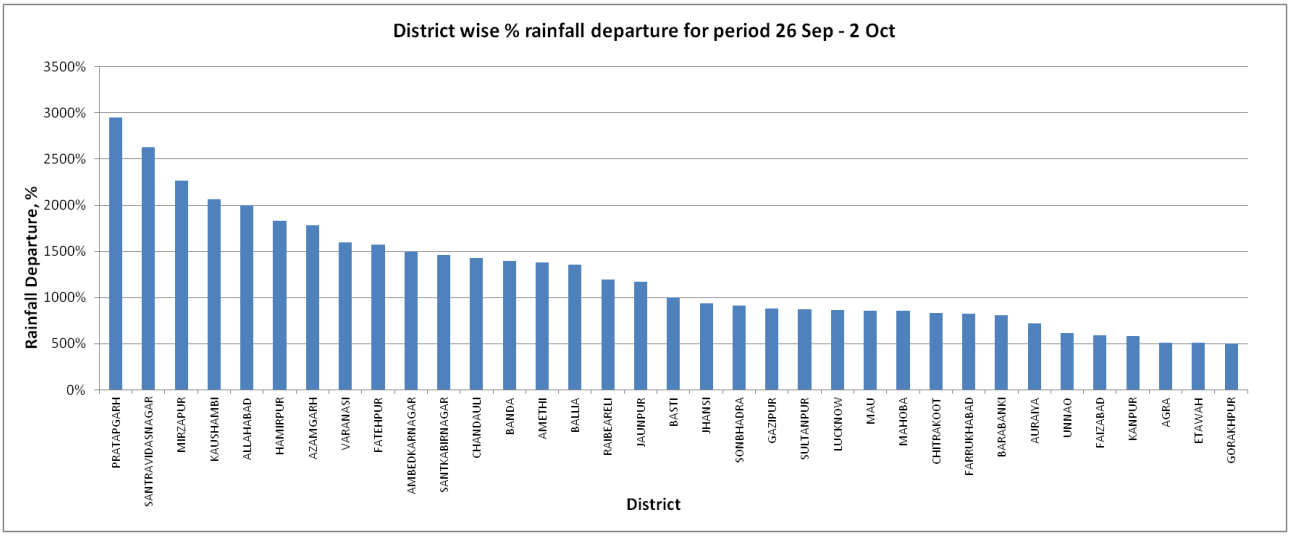

Figure 4: District wise % rainfall departure - Uttar Pradesh - 26th September to 2nd October

Following the incessant rains, water levels in all the major rivers in Bihar increased drastically and were about 1-1.5 m above the danger level at many locations. The main river systems in Bihar are *Kamla Balan*, *Bagmati*, *Punpun*, *Son*, *Mahananda*, *Burhi Gandak*, *Gandak*, *Kosi* and *Ganga*. The *Ghaghara* River which originates in Nepal, traverses through Uttar Pradesh and meets the river Ganga in Saran district of Bihar. All the river systems continued to flow above danger level for 2-3 days from 26th September onwards, without any indication of fall in water levels, resulting in further swelling of the rivers. In Patna, water level of the Ganga River rose to 49.57 m against the danger level of 48.6 m.

Preliminary damages in Patna & Bihar

In Patna, normal life was thrown out of gear with knee-deep waters in almost all areas of the city, including Rajendra Nagar, Kankerbagh, Pataliputra Colony, few of the landmark residential areas. Majority of the roads and railway lines got inundated, besides severely affecting the functioning of

healthcare services, educational institutions and power supply. Almost all platforms of Patna railway station got submerged resulting in cancellation of over dozen trains and diversion of many other trains which runs through the city. Businesses and commercial establishments were also hit badly as even drug stores were forced to keep the shutters down for fear of the stocks getting damaged and even swept away by gush of water. Flood waters had also entered many power sub-stations which affected functioning of sump-houses worsening the existing flood and water-logging situation. Floodwater intermixed with sewage in parts of the city and entered built-up areas, further increasing the stench and raising fear of a potential public health crisis. Several wall/roof collapse incidents were also reported from various parts of the city. Around 4,000 people were rescued from the flood-affected areas of Patna.

It has been estimated that more than **10 million residents** of the state have been affected and the flood and water-logging conditions in SWM 2019 resulted in the **death of more than 150 people** as per BSDMA (Bihar State Disaster Management Authority) reports.

The flood and water-logging condition that occurred during the last week of September severely affected **32 districts** in Bihar and the **worst affected districts** includes Begusarai, Bhagalpur, Bhojpur, Buxar, Darbhanga, Gopalganj, Jehanabad, Katihar, Khagaria, Lakhisarai, Madhepura, Madhubani, Munger, Muzaffarpur, Nalanda, Patna, Saharsa, Samastipur, Saran, Sheikhpura, Sheohar, Siwan, Supaul and Vaishali.

The following table summarizes **the extent of damages/inundation experienced** by the state:

Table 2: Extent of damages/inundataion experienced by Bihar - September 26th to October 2nd

District	% Built-Up Area Inundated	Inundated Road Length, Km			% of Total Crop Area Inundated
		Highways	Main Roads	Other Roads	
Araria	0.87%	1.26	0.40	9.08	3.19%
Arwal	0.09%	0.00	0.19	0.05	0.17%
Aurangabad	0.00%	0.00	0.00	0.00	0.00%
Banka	1.75%	0.00	1.09	10.95	6.18%
Begusarai	13.45%	14.78	11.16	73.05	22.52%
Bhagalpur	11.41%	27.16	40.33	169.32	33.71%
Bhojpur	5.76%	11.65	15.62	88.47	16.15%
Buxar	1.25%	0.00	6.51	16.34	4.59%
Darbhanga	15.08%	6.97	37.32	188.06	31.83%
Gaya	0.02%	0.00	0.05	0.30	0.05%
Gopalganj	4.86%	3.24	2.98	35.36	7.56%
Jamui	0.52%	0.00	1.96	10.41	1.73%
Jehanabad	11.55%	11.39	9.40	30.57	14.47%
Kaimur (Bhabua)	1.22%	0.12	2.40	10.02	1.65%
Katihar	5.65%	7.68	4.13	122.69	10.21%
Khagaria	19.63%	14.45	8.81	108.23	36.85%
Lakhisarai	14.95%	5.50	12.50	106.66	35.29%

District	% Built-Up Area Inundated	Inundated Road Length, Km			% of Total Crop Area Inundated
		Highways	Main Roads	Other Roads	
Madhepura	2.24%	7.42	4.29	34.31	9.17%
Madhubani	5.95%	9.68	12.16	120.71	12.22%
Munger	17.64%	7.89	35.48	50.57	32.93%
Muzaffarpur	5.15%	5.09	9.35	90.91	12.68%
Nalanda	8.70%	9.69	28.79	124.03	20.36%
Nawada	0.29%	0.00	2.46	2.97	0.70%
Patna	13.01%	34.30	145.33	150.14	28.88%
East Champaran	1.45%	4.30	7.51	32.94	3.28%
Purnia	1.39%	1.48	2.30	26.98	3.15%
Rohtas	0.57%	1.81	2.61	5.24	0.73%
Saharsa	8.87%	0.26	0.40	15.03	10.69%
Samastipur	3.60%	0.84	11.50	113.65	13.82%
Saran	6.05%	22.03	5.21	85.21	17.78%
Sheikhpura	9.28%	0.06	3.36	30.07	19.84%
Sheohar	7.85%	1.11	9.18	9.92	8.31%
Sitamarhi	3.19%	3.13	10.65	29.26	6.23%
Siwan	11.43%	3.23	31.80	84.57	17.67%
Supaul	2.01%	3.77	1.52	18.56	6.57%
Vaishali	6.72%	3.49	16.72	77.98	20.13%

Disclaimer

This report contains analysis that is based on publically available data. RMSI's analysis is based on the scientific data, mathematical and empirical models, and encoded experience of scientists and specialists. As with any model of physical systems, the actual extents and intensities from catastrophic events may differ from the results of simulation analyses. Furthermore, the accuracy of the estimated flood/water-logging presented in this report is highly dependent on the accuracy and quality of the data available. RMSI specifically disclaims all responsibilities, obligations, and liability with respect to any decisions or advice made or given as a result of the information in this report.