

## **Floods In Bagmati Basin And Its Shifting Courses In Muzaffarpur District**

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### **ABSTRACT**

*The Bagmati River runs through the Kathmandu Valley of Nepal and separates Kathmandu from Patan. It is considered holy by both Hindus and Buddhists. A number of Hindu temples are located on its banks. The importance of Bagmati also lies in the fact that Hindus are cremated on the banks of this holy river, and Kirants are buried in the hills by its side. According to the Nepalese Hindu tradition, the dead body must be dipped three times into the Bagmati River before cremation, so that the reincarnation cycle may be ended. The chief mourner (usually the first son) who lights the funeral pyre must take a holy river-water bath immediately after cremation. Many relatives who join the funeral procession also take a bath in the Bagmati River or sprinkle the holy water on their bodies at the end of cremation. The Bagmati River purifies the people spiritually. There is no effect of flood in most of the areas that it touches, but it has caused widespread sufferings to the people in Terai and northern districts of Bihar. In 1993, people have seen the worst destruction by this river. Poor water management, lack of proper weather forecasting and awareness were the main cause of mass destruction. Changes in temperature, precipitation and river discharge pattern could be considered as indicators of hydroclimatological changes of the river basins. In this study, the temperatures (maximum and minimum), precipitation, and discharge data from 1980 to 2009 were used to detect the hydroclimatological changes in the Bagmati River Basin, Nepal. Simple linear regression and Mann-Kendall test statistic were used to examine the significant trend of temperature, precipitation, and discharge. Increasing trend of temperature was found in all seasons, although the change rate was different in different seasons for both minimum and maximum temperatures. However, stronger warming trend was found in maximum temperature in comparison to the minimum in the whole basin. Both precipitation and discharge trend were increasing in the pre-monsoon season, but decreasing in the post-monsoon season.*

**KEYWORDS:-** Bagmati River Basin hydroclimatological change temperature precipitation discharge

### **INTRODUCTION**

The Chobar gorge cuts through the Mahabharat Range, also called the Lesser Himalaya. This 2,000-to-3,000-meter (6,600 to 9,800 ft) range is the southern limit of the "middle hills" across Nepal, an important cultural boundary between distinctive Nepali and more Indian cultures and languages, as well as a major geological feature. The basin of the Bagmati River, including the Kathmandu Valley, lies between the much larger Gandaki basin to the West and the Kosi Basin to the east. These adjacent basins extend north of the main Himalayan range and cross it in tremendous gorges, in fact, the Arun tributary of the Kosi extends far into Tibet. The smaller

Bagmati rises some distance south of the Himalaya. Without glacial sources, its flow is more dependent on rainfall, becoming very low during the hot season (April to early June), then peaking during the monsoon season (mid-June to mid-August). In these respects, the Bagmati system resembles the (West) Rapti system lying between the Gandaki basin and the Karnali basin in the far west of Nepal. The Bagmati originates where three headwater streams converge at Bāghdwār (Nepali: बाघद्वार, "Tiger Gate"), where the water flows out through a gargoyle shaped like a tiger's mouth. This lies above the southern edge of the Shivapuri Hills about 15 kilometers (9 mi) northeast of Kathmandu. Here the Bagmati is wide and swift with a high load of suspended solids, giving it a grey appearance. The river flows southwest about 10 km (6 mi) through terraced rice fields in the Kathmandu Valley. Resistant rock strata interrupt the flow in places, including at Pashupatinath Temple. Beyond the temple, the river flows south until joined by the larger west-flowing Monahara River, then turns west itself. After entering Kathmandu's urban area more tributaries enter: relatively unpolluted DhobīKholā and sewage-laden TukuchaKholā. Then the river bends south and the Vishnumati enters from the right at TekuDovan. The Vishnumati also rises in the Shivapuri Hills, some 6 kilometers (4 mi) west of the Bagmati's source. It flows south past Nagarjun Hill and Forest Reserve, Swayambhu Stupa and Durbar Square in Kathmandu. As it passes the centre of Kathmandu, this tributary becomes heavily polluted and choked with trash.

### **OCCURRENCE OF FLOODS IN RIVER SYSTEMS**

A study has been made to see the flood stages in various river systems during floods in FMISC focus area. It was found that early flood takes place during the month of May-June in River Bagmati, Kosi and river Kamla. There after flood generally comes in River Bagmati month of mid July. During these months River Ganga generally remains low but by September River Ganga, the master drain also rises making the flood problem more acute. A peculiarity of this year's flood is regarding the river Bagmati in which flood remained high even during the month of September –October.

**FLOOD HAS A HISTORY IN MUZAFFARPUR DISTRICT**

**Muzaffarpur** is the worst flood-prone and flood-affected Bihar. Floods are an annual certainty in Bihar. This was confirmed by the data presented by the home ministry in the Lok Sabha in July this year. Muzaffarpur tops the list of states in terms of death of citizens due to floods. A total of 970 people were killed in Muzaffarpur(Bihar) during 2016-19 followed by 756 in Kerala, 663 in West Bengal and 522 in Maharashtra - 6,000 died across India due to floods. Two of the severest floods in Muzaffarpur were seen in 1987 and 2004. The 1987 flood was unique as most of India witnessed drought-like situation due to what many call "mid-way flight of the monsoon". Around 1,500 people were killed in Muzaffarpur in the 1987 flood. It was followed by a massive earthquake in 1988. On both occasions, the state government was found lax, fueling people's anger.



This is a photograph, shows patients being taken to the hospital wading through floodwater. Several are as of Muzaffarpur are under waist-deep water. (Photo: PTI)

In the next election, the Congress was voted and practically rooted out of Muzaffarpur. This was 1989. Lalu Prasad emerged as the mass leader. The Congress has been tottering ever since. The next big flood was in 2004, when about 900 people lost their lives. The Lalu Prasad government was voted out in 2005. His Rashtriya Janata Party remained in political exile for the next ten years. Lalu Prasad had to forge an alliance with Nitish Kumar and hype on anti-Modi sentiments to come back to power, which the RJD lost in just two years' time.



In Muzaffarpur's Mithansarai and Madhopur villages, for example, boats are being used to ferry stranded villagers. Meanwhile, in Mustafapur, Darbhanga district, men are building their own boats to facilitate rescue work because the district administration has not provided them with enough vessels to ferry people to the nearest shelter. Nearly 100 families are living in makeshift shelters on this highway. Humans and cattle share space in these tiny tents. Children struggle to extract potable water from borewells, even as their homes remain under water. The areas generally affected by floods in West Champaran are the areas around Ramnagar, Narkatiaganj, Mainatand and Chanpatia etc. and in East Champaran Sugauli, Motihari and Lalbegiaghat etc. Motihari town is frequently affected due to spill of Sikrahana river (Bagmati is known as Sikrahana in its upper reaches). Bagmati is almost fully embanked in the lower reach i.e. the stretch from Motihari to its outfall in Ganga, except few gaps in the left embankment near

Muzaffarpur town when the Bagmati spills meet the Burhi Gandak river. In this reach the main flood problem is not due to inundation of the area but the erosive action on the banks of the river which causes breaches in the embankments even in medium floods almost every year at number of places. This leads to flood fighting works at the corresponding sites for protection of the embankment. Erosion is more severe from downstream of Muzaffarpur town till its outfall, which when not contained appropriately causes breach of embankments at the eroded sites frequently.

#### **CLIMATE AND RAINFALL**

FMIS area has monsoon type tropical climate with high temperature and medium to high rainfall. The temperatures are lowest during December-January with an average minimum of

8<sup>0</sup> C to 10<sup>0</sup> C and maximum of 24<sup>0</sup> C to 25<sup>0</sup> C. The temperatures in the hottest months of April to June are minima 23<sup>0</sup> C to 25<sup>0</sup> C and maxima 35<sup>0</sup> C to 38<sup>0</sup> C. The mean annual rainfall for the State is about 1270 mm varying from 1170 to 1580 mm in the Focus area. Most of the rainfall (80% to 90%) is received from mid-June to mid-October. The late September-October rains (locally known as 'Hathia'), though only 50 to 100 mm in quantity, are very crucial to agriculture in the region and their timing and distribution make all the difference between plenty and scarcity. A striking feature of this year rainfall pattern concerned with Sikandarpur in Muzaffarpur where a total of 3900.3mm occurred during 15<sup>th</sup> June to 18<sup>th</sup> October 2017.

### **HEAVY RAINFALL TO FLASH FLOODS IN BIHAR**

A total of 25.72 lakh people have been affected by the natural calamity floods normally struck north Bihar in August or, sometimes, in September, but this time they came a month earlier primarily because of unusually heavy rainfall in the Terai region of the neighbouring country. For the last three-four days, the Terai region of Nepal has been lashed by rainfalls ranging between 280-300 mm which was many times higher than the 50 mm which is considered normal for the area during this time of the year. As a result, several rivers in Bihar like Kosi, Bagmati and Mahananda have been in spate, the Chief Minister said in the House. Twelve districts Madhubani, Sitamarhi, Sheohar, East and West Champaran, Supaul, Darbhanga, Muzaffarpur Katihar, Purnea, Kishanganj and Araria have been affected by the floods. He cited the example of the catchment area for Kamala river in Nepal which received 203.60-319.80 mm of rainfall on July 12 -13. This led to a massive discharge of water in the river which passes through Jayanagar in Madhubani district. Water has inundated a road bridge in Jayanagar while in Jhanjharpur water level at a rail bridge has reached 54.50 metres, which is higher than the all-time record of 54.34 registered in 1987. The Kamala Balan embankment has been breached at six places, affecting several blocks of Madhubani and Darbhanga districts. Water level in the Bagmati has broken previous records at several places affecting people in Sheohar, Sitamarhi and Muzaffarpur districts. All embankments along the Bagmati have, however, so far remained unharmed. Besides, a dam over Khiroi river burst in Darbhanga district affecting many villages. Excessive water discharge in Mahananda has inundated large parts of Kishanganj district. All embankments in the Mahananda basin are, however, secure till now. Till 10 am Tuesday, 25 people have died in the floods and instructions have been issued for prompt payment of ex-gratia to the next of their kin. The flood-hit area covers 555 Panchayats of 78 blocks spread across these districts. Rescue work is being carried out by 796 personnel equipped with 125 motor boats. Besides 26 teams of NDRF and SDRF are engaged in the rescue operations and so far 1.25 lakh people have been evacuated from the marooned areas.

For those displaced by floods, 199 relief camps have been set up which are at present inhabited by 1.16 lakh people. Their food is being prepared at 676 community kitchens. Instructions are in place for setting up more relief camps and community kitchens if such a need arises. Good quality of food and drinking water is being ensured and so is availability of bleaching powder and chlorine tablets, ORS and anti-diarrhea drugs. The Chief Minister, who has conducted aerial surveys of the affected areas in the past few days, said top officials of village development and road construction departments have been asked to personally take stock of the damage that has been caused so that rebuilding programme are initiated once the situation is normal.

### **FLOODS IN LAST TEN YEARS IN THE FMIS FOCUS AREA**

Floods have caused devastation and acute human sufferings frequently since the dawn of civilization

and man has had to live with floods since time immemorial. The impact of flood was perhaps not felt to the same extent in the past as is felt now. This was due to the fact that there were smaller living population and pressures of industrial activities and other development works in the flood plains was far less compared to the present day activities. The flood problem was accentuated due to ever increasing encroachments on the flood plains by the growing population to meet its requirements of food and fiber. The destruction of forests for reclaiming areas for occupation and for obtaining fuel for domestic requirements had also caused changes in river regime. All these have resulted in an anomalous situation where, in spite of protection measures carried out so far in the State with a substantial investment on flood management works flood damages have gone on increasing instead of decreasing. A brief summary of flood based on the Water Resources Department Annual Flood Report in chronological order during (1997-2017) is given as follows: **2017** During this year rainfall in the catchments of all the river basins was generally normal. Gandak, Kosi, Bagmati and Mahananda rivers experienced floods from first week of July. In the mid of July maximum discharge caused tremendous pressure to the embankment/ structures resulting in wide spread damage. Bagmati right embankment at Kothia village, Bagmati afflux bund at Mausurha closure, right embankment of Bagmati at Beria Thoral, Gvindpur and Paharpur, Kamla Balan river at 65.5 Km, were partially damaged. Afflux bund and main eastern Kosi embankment were damaged at few places which were protected by undertaking flood fighting works. Besides these few places at Burhi Gandak, Bagmati, Kamla and Kosi, river embankments faced severe erosion which was protected by flood fighting works.

### **MONTHLY / MONSOON RAINFALL (MM) OBSERVED IN THE RIVER BASINS OF AOI\_ FLOOD 2017**

River Basins	Rain-Gauge Stations	Monthly Rainfall					Monsoon 2017		Normal Monsoon Rainfall
		June (from 15th)	July	August	September	October (up to 18th)	Total	No. of rainy days	
1	2	3	4	5	6	7	8	9	10
Burhi Gandak	<i>Simara</i>	291.60	862.20	665.70	739.30	27.60	2586.40	64	1497.40
	Lalbegiaghat	61.10	562.40	983.90	572.60	76.80	2256.80	63	
	Sikandarpur	136.40	1023.00	1106.40	1230.08	449.60	3945.48	66	
	Samastipur	165.20	630.20	383.60	542.00	49.80	1770.80	66	
	Rosera	141.00	459.60	394.40	394.20	34.20	1423.40	62	
	Khagaria	149.40	611.50	214.60	309.50	55.60	1340.60	49	
Bagmati	<i>Kathmandu</i>	134.00	234.50	226.16	329.70	18.30	942.66	87	1125.60
	<i>Nagarkot</i>	231.40	226.80	353.35	422.60	1.20	1235.35	72	1554.30
	Benibad	125.20	620.20	323.20	530.50	103.00	1702.10	59	
	Hayaghat	46.20	640.50	379.20	691.40	85.80	1843.10	76	
	Kamtaul	193.00	528.00	448.10	422.50	148.90	1740.50	53	
	Sonbarsa	216.20	810.80	509.80	316.00	53.40	1906.20	50	
	Saulighat	NA	NA	577.80	629.60	133.70			
Kamla	Jainagar	253.90	622.40	226.00	245.00	34.60	1381.90	55	
	Jhanjharpur	133.60	544.40	593.70	428.10	25.50	1725.30	64	
Kosi	<i>Okhaldunga</i>	140.30	508.90	250.00	420.30	49.80	1369.30	88	1401.60
	<i>Taplejang</i>	109.40	456.10	323.40	305.90	116.60	1311.40	101	1404.60
	<i>Dhankutta</i>	82.10	253.00	93.20	166.00	19.80	614.10	72	722.50
	<i>Biratnagar</i>	211.80	424.10	521.80	375.80	1.60	1535.10	75	1522.50
	<i>Dharan</i>	204.50	573.40	305.50	387.60	145.30	1616.30	88	
	Basua	117.80	397.43	342.50	375.00	10.40	1243.13	64	
	Baltara	285.00	374.40	230.60	243.40	47.00	1180.40	53	
	Kursela	244.00	343.20	197.60	151.60	2.20	938.60	55	
	Birpur	NA	NA	386.20	446.00	6.60			

1. Rain-gauge stations written in italics are located in Nepal.

Notes:

2. Monthly / monsoon rainfall have been calculated using daily rainfall obtained from CWC and Nepal web site [www.mfd.gov.np](http://www.mfd.gov.np). Underlined figures for Sonbarsa and Jainagar have been taken from Directorate of Statistics.

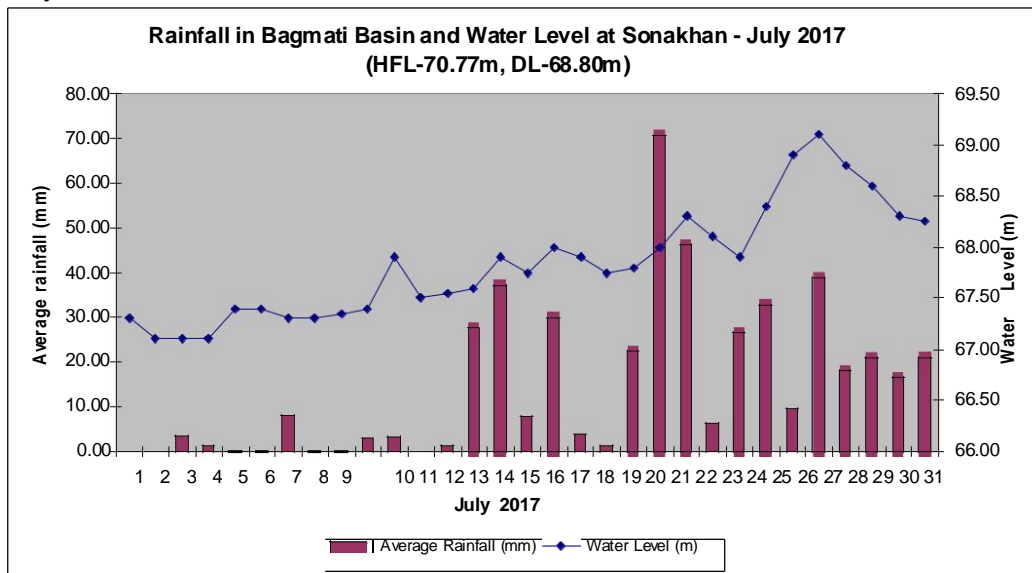
3. Source of Normal Monsoon Rainfall is the Nepal web site [www.mfd.gov.np](http://www.mfd.gov.np)

A word of precaution note here is that there have been a few days on which data was not available. Those gaps have not been filled up. So, similar information from the parent source may be a little different. If we look at the above Table, we find that most of the places have received rainfall on more than 50% days of the monsoon period. Taplejung in Nepal had maximum (101) rainy days. If we compare this monsoon rainfall with the Normal Monsoon Rainfall, it reveals that the monsoon has been more active in the western part of the area (Bagmati basin). Eastern part (Kosi basin) received less than the Normal rainfall. Sikandarpur received 3945.00mm cumulative monsoon rainfall which is more than three times the Normal Monsoon Rainfall of the area. Below are the contours drawn with

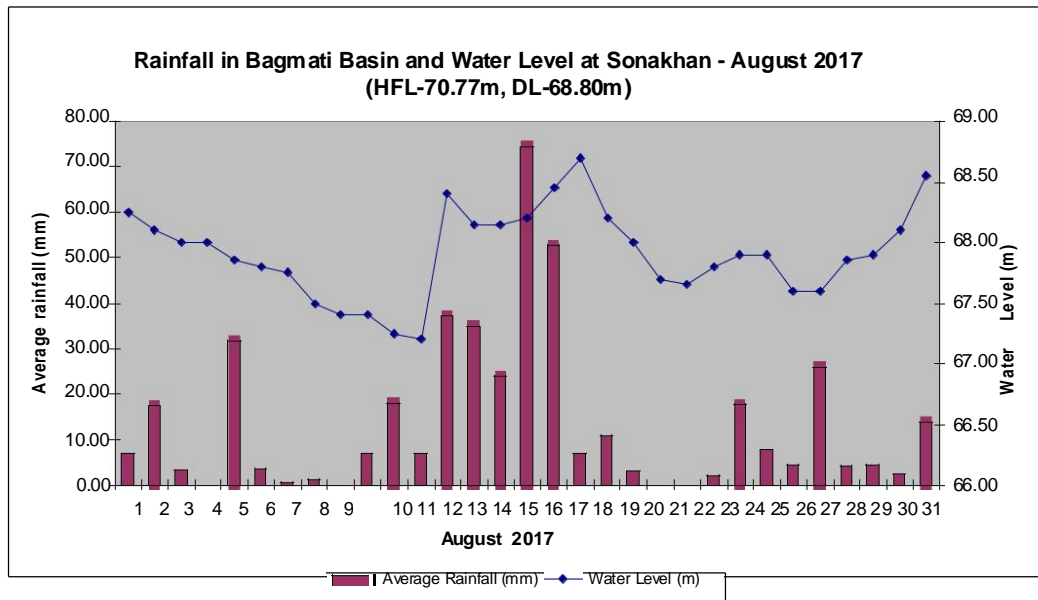
the rainfall figures given in the above Table. The June rainfall is taken from 15<sup>th</sup> of the month and the October rainfall is only upto 18<sup>th</sup> of the month.

**BAGMATI**

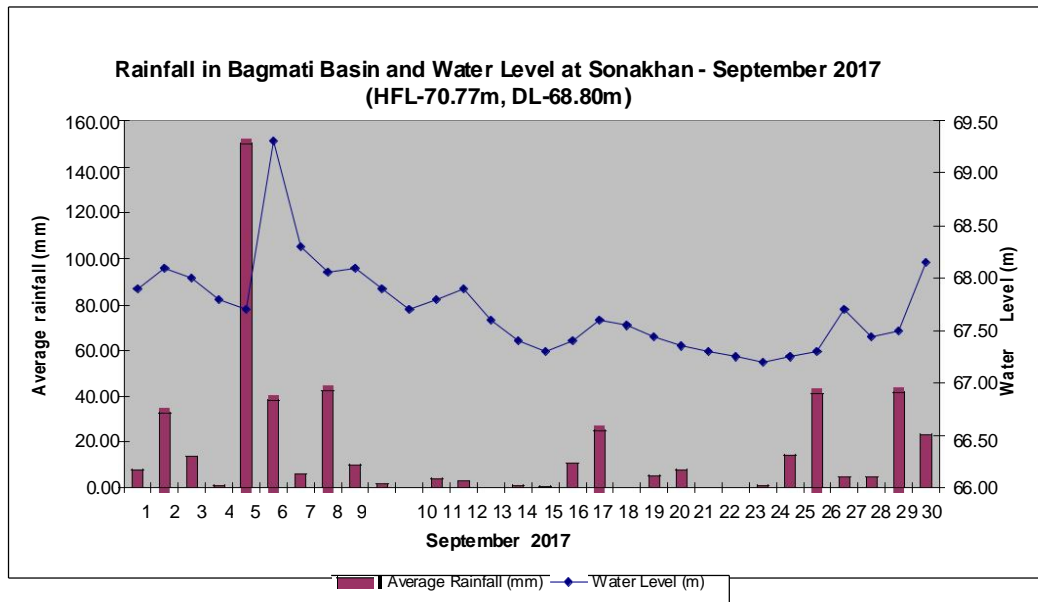
Like Bagmati basin, Bagmati also received good amount of rainfall (average 65.5mm) on 15<sup>th</sup> June (first day of the monsoon season) which is reported to have caused sudden rise in the water level and consequent damage. There was continuous rainfall from 23<sup>rd</sup> to 28<sup>th</sup> June, maximum being 78mm on 25<sup>th</sup>. River water level at Sonakhan is available from 23<sup>rd</sup> only which shows slow but continuous rise in the month of June from 67.20m to 67.40m.



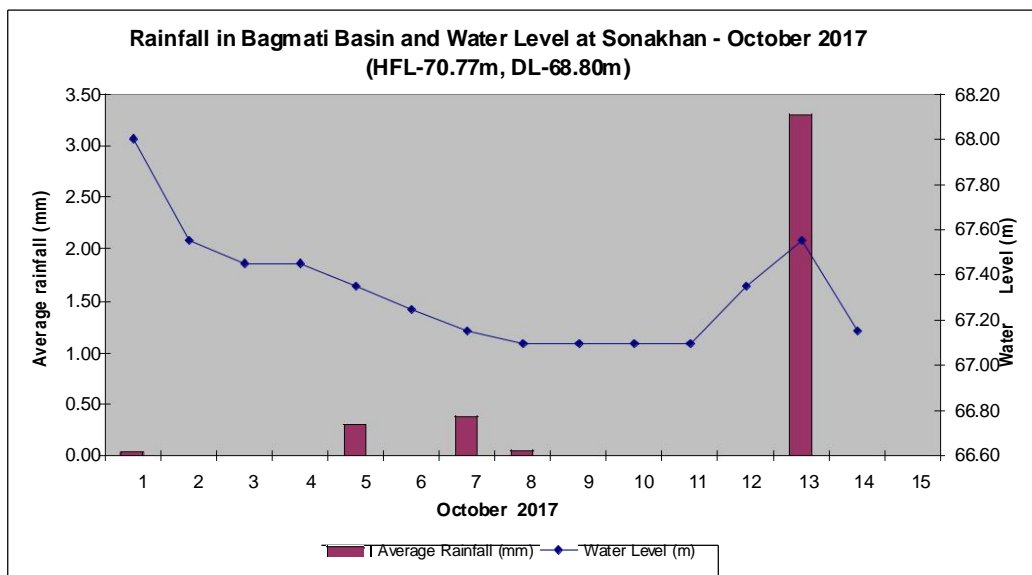
In July, there has been regular rainfall (28 rainy days) which kept the river water level continuously rising. Maximum average rainfall of 70.5mm was observed on 21<sup>st</sup>. Rise was steep from 27<sup>th</sup> to 29<sup>th</sup> when level went from 67.90m to 69.10m. It is interesting to note that most of the time effect of rainfall has been observed on the same day.



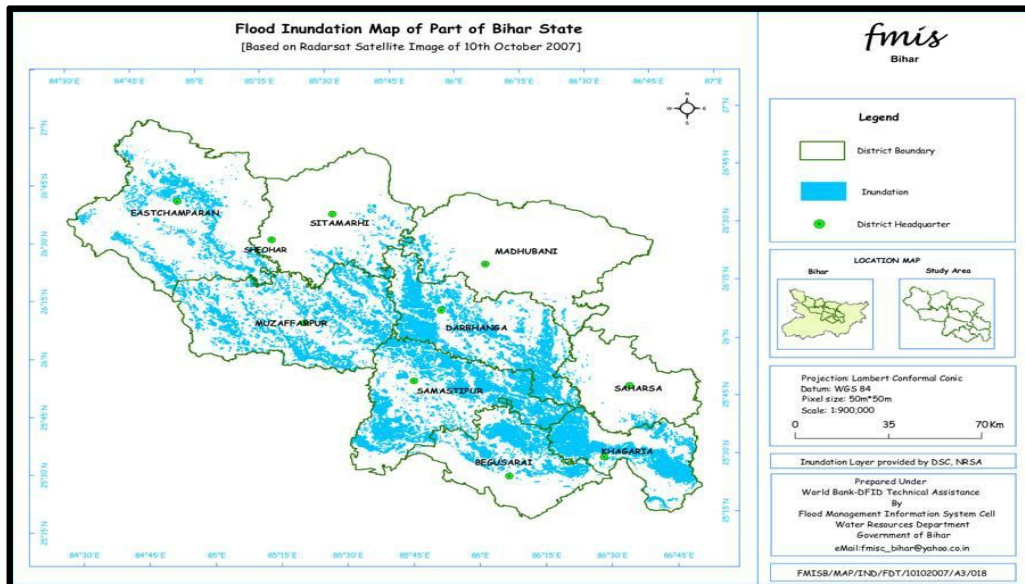
In August also, there has been regular rainfall with 27 rainy days. However, rainfall from 10<sup>th</sup> to 20<sup>th</sup> August has resulted in significant rise in water level. On 12-13 level rose from 67.20m to 68.40m and on 18<sup>th</sup> it reached to 68.70m. Again it is interesting to note the rise from 67.60m on 27<sup>th</sup> to 68.55m on 31<sup>st</sup> when the rainfall observed was quite low. In September, maximum average rainfall of 149.73mm (season’s maximum) was observed on 5<sup>th</sup> which caused steep rise in water level from 67.70m on 5<sup>th</sup> to 69.30m on 6<sup>th</sup>. During the rest of the month, rainfall was low and the water level decreasing except the last week when slight rise was marked.



In October there was almost no rainfall up to 15<sup>th</sup>, however, rise in the water level of 0.45m was observed on 11-13<sup>th</sup>. It seems four rain gauge stations could not capture the rainfall occurred in some pockets.



A sample inundation map of 10<sup>th</sup> October 2017 is shown below.



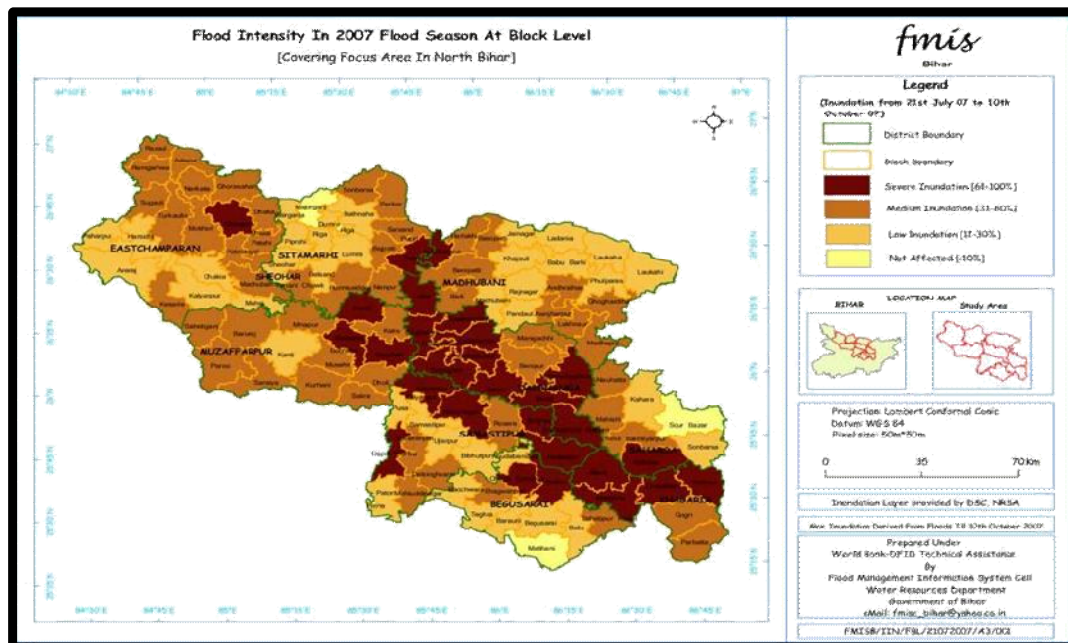
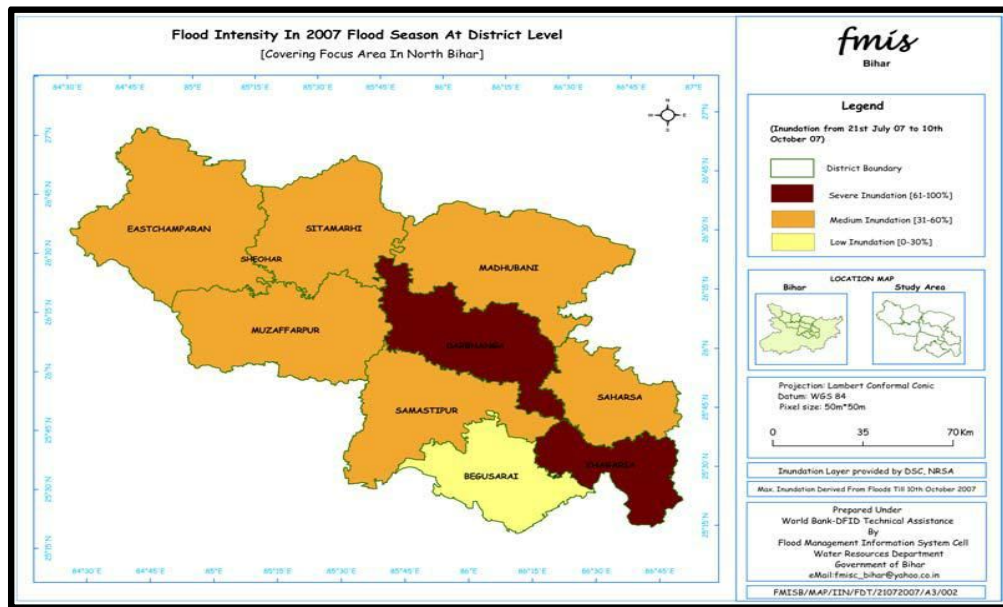
**Inundation Map of Part of Bihar State 10<sup>th</sup> October 2017.**

Statistics of Inundated Geographic Area of Part of Bihar state on 10<sup>th</sup> October 2017:

Sl. No.	District Name	Actual Area (Hectares)	Inundation (Hectares)	Inundation (%)
1	Khagaria	148600	51109	34
2	Darbhanga	227900	66207	29
3	Samastipur	290400	80614	28
4	Begusarai	191800	34152	18
<b>5</b>	<b>Muzaffarpur</b>	<b>317200</b>	<b>51508</b>	<b>16</b>
6	East Champaran	396800	26343	7
7	Sitamarhi + Sheohar	264300	6049	2
8	Saharsa	169200	2187	1
9	Madhubani	350100	4366	1
	<b>Affected Area</b>	<b>2356300</b>	<b>322535</b>	<b>14</b>

**FLOOD INTENSITY MAP**

The maps are prepared using the 15 numbers of Radarsat scenes as referred in above paragraph. This has been prepared for district level and block level at the end of season of monsoon 2017.



**Flood Intensity Map in flood season 2017 for DMD at District level.**

The flood statistics below shows the district wise maximum inundation during the flood season 2017 and is a by product of above maps. The basis of making these maps are 15 numbers of scenes of different date from 21<sup>st</sup> July to 10<sup>th</sup> October which were the RADARSAT data and fully covered the focus area. The exact date can be referred from table at 4.5.1. The maximum inundation percentage indicates the percentage with respect to the inundation area to the geographical area of the district. It has been categorized in three distinct flood intensity group as severe, medium and low.

**CONCLUSION**

A breach occurred in Bagmati left embankment (at 72-73 km) near Basahi Village in Begusarai District on August 03, 2007 at 1:45 am. It caused inundation in the adjoining areas. A case study was done in the FMISC to see the inundation effects of the breach on the adjoining blocks: Khudabandpur, Cheria-Bariarpur and Bakhri all, in Begusarai District. Four RADARSAT images of 28<sup>th</sup> July, 4<sup>th</sup>, 6<sup>th</sup> /7<sup>th</sup> and 9<sup>th</sup> August, 2017 were used in the study. River water level observed at Samastipur and Rosera as well as rainfall observed in the basin up stream of the breach location from August 2 to 9 were also reviewed. It is observed that an area of only 1896 Hectares (Ha) in the above mentioned three blocks was inundated on 28<sup>th</sup> July 07. After breach on August 3 the inundation increased rapidly and it became 6722 Ha on 4<sup>th</sup>, 9002 Ha on 6<sup>th</sup> and 9188 Ha on 9<sup>th</sup> August. The rate of increase of the area under inundation is fast during the first 2-3 days and slows thereafter. Block wise inundation on the above dates can be seen in the following Table.

**Inundated area on different dates due to breach in Burhi Gandak.**

Name of Block		Inundated Area (Hect.)			
		28/07/2017	4/08/2017	6/08/2017	9/08/2017
1	Khudabandpur	21	235	289	310
2	Bakhri	95	387	1202	1385
3	Cheria Bariarpur	1779	6100	7511	7492
<b>Total Affected Area</b>		1896	6722	9002	9188

Two river gauge stations of CWC are located at Rosera and Samastipur in the up stream of the breach location. Rosera is about 25 km and Samastipur 65 km from the breach location. It can be seen from the following Table that the breach has significant effect on the river water level at Rosera where it dropped by 0.44m from August 3 to 6 and by 1.09m from August 3 to 9. The drop is not of this extent at Samastipur. Water level on different dates can be seen in the following Table:

**Table Water level at Samastipur**

Sr. No.	Date	Average <sup>1</sup> Rainfall (mm)	Water level (m) at Samastipur (HFL-49.38m, DL-46.02m)	Water level (m) at Rosera (HFL-46.35m, DL-42.63m)	Remarks
1	2/8/2007	29.28	48.87	45.80	
2	3/8/2007	10.36	49.23	46.03	
3	4/8/2007	2.6	49.23	45.74	
4	5/8/2007	0	49.22	45.68	
5	6/8/2007	0	49.11	45.59	
6	7/8/2007	7.28	48.99	45.41	
7	8/8/2007	7.72	48.75	45.17	
8	9/8/2007	0.8	48.51	44.94	

Average of the rainfall at Simara, Lalbegiaghat, Sikandarpur, Samastipur and Rosera. Average daily rainfall in the basin up stream of the breach location after the occurrence of the breach is observed less than 10 mm.

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