fmisc
Bihar

Flood Management Improvement Support Centre

FLOOD REPORT 2011

Water Resources Department
Government of Bihar

Towards a Culture of Preparedness for Better Flood Management

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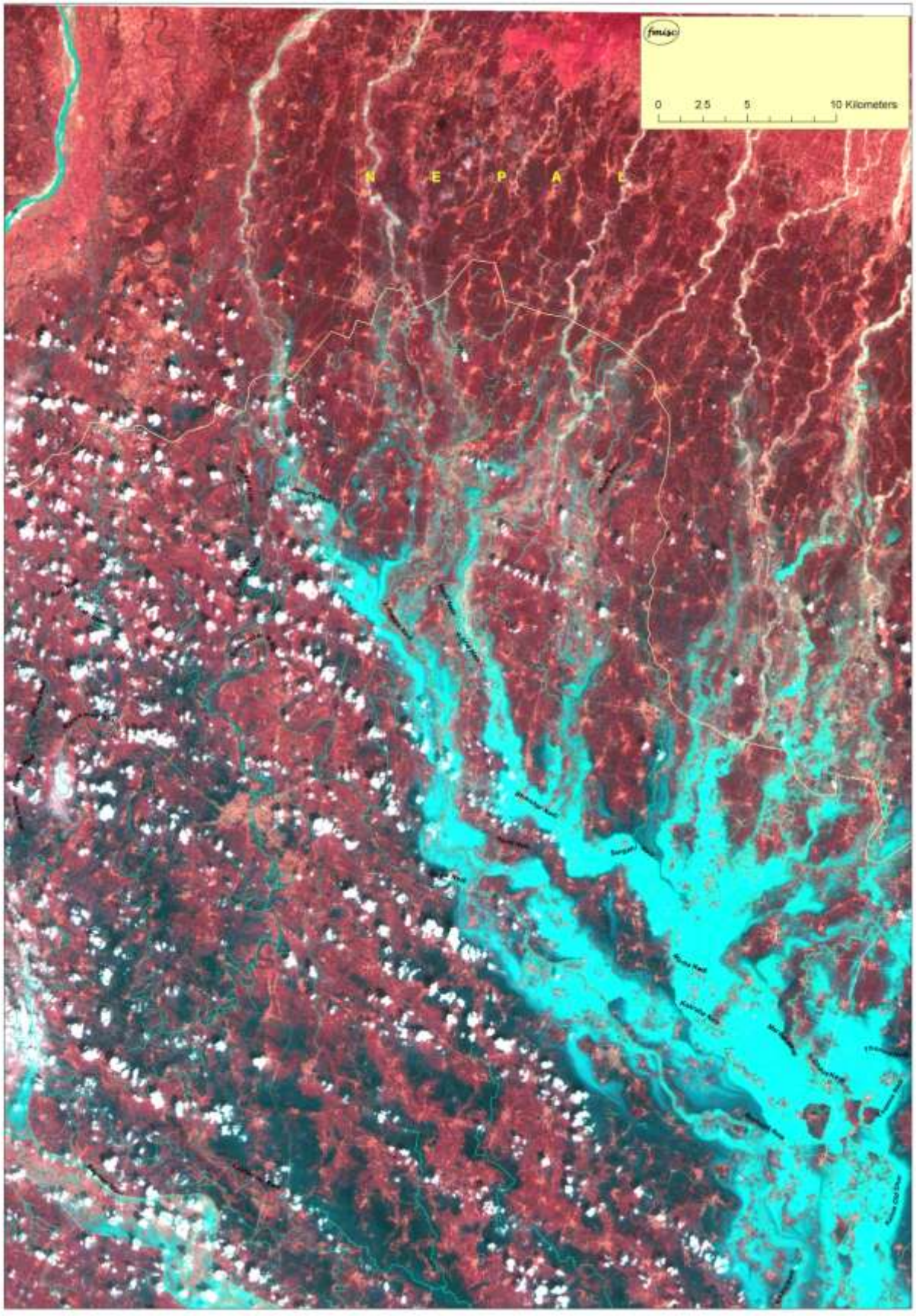

Adhwara Group of Rivers, as seen by satellite on 30th Sep 2011. These rivers enter Bihar as separate rivers but mingle with each other during high floods, leaving no trace of "watershed" in-between. This is a 'sheet flow' area.

Foreword

*I am proud to forward this **'Flood Report 2011'** prepared by our Flood Management Improvement Support Centre, Patna. This is the fifth annual report since its inception in the year 2007. Flood Management Improvement Support Centre (FMISC) was set up under the aegis of the Water Resources Department, Government of Bihar with the objective of improving flood management practices in the State by introducing the use of Remote Sensing, Geographic Information System (GIS) and modeling techniques. This report gives a brief account of the 2011 floods and demonstrates the usefulness of modern technological tools like GIS and Remote Sensing in Flood Management.*

In Phase I, only eleven flood prone districts of north Bihar were in the focus area of FMISC. Now all the 21 districts of north Bihar and Patna, Munger and Bhagalpur districts of south Bihar have been brought under the FMISC focus area. During the period, information and data regarding observed rainfall, 3 day rainfall forecast, river gauge levels, trend forecast of CWC and WRD gauge sites within flood prone districts of north Bihar were collected and sent to National Remote Sensing Centre, Hyderabad which in turn, delivered near real time satellite imageries and inundation layers. Based on the collected data, number of information products such as flood inundation maps, breach maps etc. were prepared in near real time and disseminated to stakeholders.

The products generated by FMISC were found very helpful for disaster management measures undertaken by the Government of Bihar. Satellite customized images were found very useful in planning anti-erosion and river training works to be undertaken before the flood 2012 season.

FMISC is on the move, and with introduction of new technological innovations, we hope to go further in giving support to mitigate the sufferings of the people of flood prone areas.

(Afzal Amanullah)
Principal Secretary,
Water Resources Department,
Govt. of Bihar

ACKNOWLEDGEMENT

Once again, FMISC has come back with **'Flood Report 2011'** which is outcome of meticulous efforts of entire FMIS team.

The contribution of the World Bank being the driving force in organizing capacity building and supporting for knowledge enhancement is highly acknowledged. Last year in October 2011, we had a workshop on **"International Approaches to Manage and Plan Embankment Assets"** in which prominent experts from US Army Corps of Engineers participated and shared their experience on *Embankment Asset Management Plan* as done in the United States and other countries. They emphasized the use of *PC Tablet* for embankment inspection to assess the actual status of the embankment. The valuable contribution of the World Bank especially of Mr. Winston Yu, Task Team Leader, Dr. S. Raj Rajagopal, Sr. Water Resources Specialist, and Dr. S.T. Chari, WB Consultant in implementing the FMIS Phase 2 Programme deserves special mention in successful steering in the implementation of the project. The Bank provided opportunities to FMIS team in participation in different training and study tour programmes like one at NESAC, Shillong and IIT, Guwahati, at ASCI, Hyderabad and at NRSC, Hyderabad. A series of other training programmes are also in the pipeline and I am extremely thankful to the Bank for providing our team with the best of the available experts related to this field. My sincere thanks are to National Remote Sensing Center, Hyderabad, India Meteorological Department, Delhi and Patna, Central Water Commission, Ganga Flood Control Commission, Disaster Management Department and Agriculture Department of GoB and NIH Patna centre who have constantly been co-operating with FMIS Centre. I am sincerely thankful to Flood Monitoring Circle of WRD for providing us useful information and their valuable suggestions in different activities being undertaken at FMISC.

Finally, I express my sincere and deepest gratitude to Shri Vijay Kumar Choudhary, Hon'ble Minister, Water Resources Department, Government of Bihar, for his guiding vision and encouraging support. My heartfelt gratitude is to Mr. Afzal Amanullah, IAS, Principal Secretary, WRD who always enlightened, inspired and supported the FMISC team in achieving its goal. In the last but not the least, I must once again mention my gratitude to Mr. Amanullah who took pain to go through this report despite of his busy schedule.

(Ajit Kumar Samaiyar)
Joint Director
FMISC, Patna

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Contents

Annexure

List of Maps

Acronyms

ALTM	Airborne Laser Terrain Mapper
AOI	Area of Interest
ASAR	Airborne Synthetic Aperture Radar
AWiFS	Advance Wide Field Sensor
CMIE	Centre for Monitoring Indian Economy
CWC	Central Water Commission
DEM	Digital Elevation Model
DFID	Department For International Development
DL	Danger Level
DMD	Disaster Management Department
DMSP	Disaster Management Support Program
DRF	Daily Rainfall
DSC	Decision Support Centre
FMIS	Flood Management Information System
FMISC	Flood Management Information System Cell
GDP	Gross Domestic Product
GFCC	Ganga Flood Control Commission
GIS	Geographic Information System
GoB	Government of Bihar
GoI	Government of India
GoN	Government of Nepal
HFL	Highest Flood Level
IMD	India Meteorological Department
LISS	Linear Imaging Self Scanning
Met.	Meteorological
MM5	Mesoscale Model 5
NRSA	National Remote Sensing Agency
RS	River Stage
SRTM	Shuttle Radar Topography Mission
WGS 84	World Geodetic System 1984
WiFS	Wide Field Sensor WRD Water Resources Department

1.0 Preamble

'Flood Report 2011' is fifth report in sequence published by Flood Management Improvement Support Centre (FMISC), Patna. The focus area of FMISC has been extended to entire north Bihar covering all 21 districts in FMIS Phase 2. It also covers districts of Patna, Bhagalpur and Munger adjoining river Ganga in south Bihar. The State felt a sigh of relief as far as monsoon is concerned as rainfall during the year 2011 has been better than normal after two consecutive years of partial drought. Naturally, production of both kharif and rabi crops are expected to be good. As far as flood scenario is concerned, we faced serious flood problems at many places, such as erosion at a number of spurs in the d/s of Vikramshila bridge and damage of revetment work near Raghopur village in the u/s of Vikramshila bridge, overtopping of Ganga Prasad Zamindari embankment under Bhagalpur Chief Engineer's jurisdiction and damages in Pataraha Chharki and P.D. ring bundh in Gopalganj district under Chief Engineer Siwan jurisdiction. Besides, flood pressures were reported on many spurs and part of embankments on river Gandak and Kosi. Some tense moments also arose due to sudden and very high intensity rainfall in the upper catchment of river Sone in Madhya Pradesh and Uttar Pradesh resulting in very high discharge and rise in water level in river Sone. As a consequence, the river Ganga level also rose later on. At many threatened sites, Engineer-in-Chiefs and Chairmen of Flood Fighting Forces camped for many days and nights and flood fighting works were executed on war footing. The situation in north Bihar Rivers was by and large under control. This was all the result of judicious selection and timely completion of anti-erosion works. This year, too, flood calendar has been published by Water Resources Department and is being strictly followed. FMISC, like previous years, has supported actively in deciding the anti-erosion works for the year 2012 flood with the help of satellite imageries. Two sessions of workshops were also organized separately for all Chief Engineers and Chairmen of Flood Fighting Forces to understand the flood situation at different locations with the help of satellite imageries. Visit of eminent experts like Dr. Shafiqul Islam from Boston University, USA and Mr. Alan Tamm and Dr. Padmakar Srivastava from US Army Corps of Engineers were added advantage for the capacity building of WRD engineers.

The FMIS website has been updated with its new home page look. Some latest information such as IMD cloud condition and To-day's weather with five days' forecast by Telerik Weather Station are new features added in our website.

This report is similar to previous report as it has short description of twelve years flood history with detail flood events of this year. In website section, new features incorporated have been discussed. Hydrologic analysis, comparison between observed rainfall and three days' forecasted rainfall, and isohyets maps based on rainfall record have been prepared to better understand the rainfall pattern and trend of water level with respect to rainfall in the catchment are also included in this report. Key information products with other important maps like *maximum inundation extent map*, *flood intensity map* along with *value added inundation maps* have also been included and analyzed in this report. A brief report on the components of FMIS phase 2 has also been added.

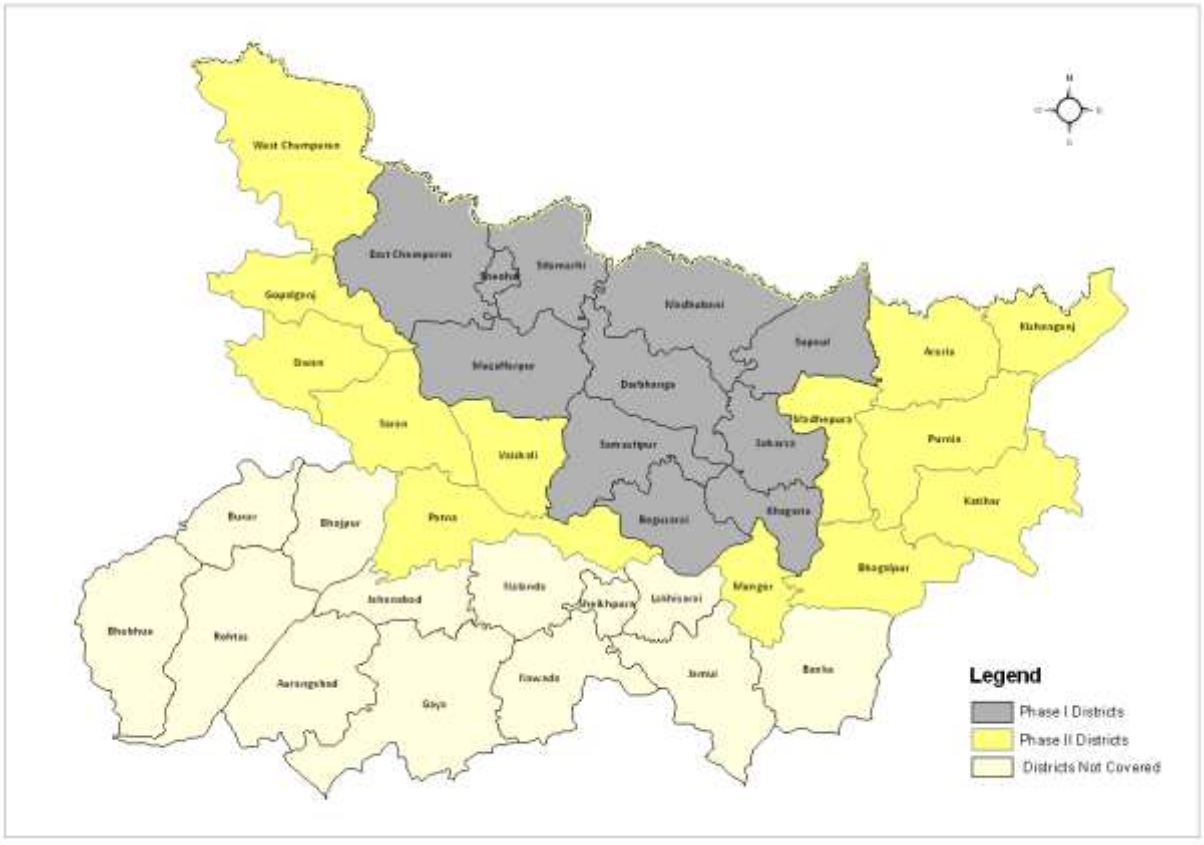
2.0 PROFILE OF FMIS FOCUS AREA

FMIS focus area is the most flood prone area in the State consisting of Mahananda, Kosi, Kamla-Balan, Bagmati, Burhi Gandak, Gandak and Ghaghra rivers. A number of minor rivers of North Bihar also falls in the focus area. Furthermore this area is a saucer shaped area between the embanked river Gandak and Kosi.

2.1 The Geographic Location of Bihar

Bihar lies between latitude 24^0 20' 10" N to 27^0 31' 15" N and longitude 83^0 19' 50" E to 88^0 17' 40" E. The total geographical area of Bihar is about 94,163 sq. km. The FMIS focus area comprising 21 districts in north Bihar and 3 districts (adjoining river Ganga) of south Bihar for phase II lies approximately between latitude 27^0 32' 7" N to $24^0$53'2" N and longitude 83^0 47' 15" E to 88^0 16' 5" E and the geographical area is about 60119 sq. km. The geographical coverage is as shown in the figure below and the colored area is FMIS focus area.

Geographical Coverage of Bihar



Map 2.1 Geographical Coverage of Bihar (Focus Area - All 21Districts of North Bihar and 3 Districts of South Bihar)

2.2 FMIS ACTIVITY AREA

The area is bounded by Himalayan foot hills and terai region of Nepal in the north, Mahananda on the east, river Ganges on the south and River Ghaghra on the west. The area comprises of rich alluvial plains of Indo-Gangetic plain. It comprises the tract of alluvial plains north of Ganga, falling between the Ganga and Indo-Nepal border having general slope from north-west to south-east and is drained by the rivers Ghaghra, Gandak, Burhi Gandak,

Bagmati-Adhwara group of rivers, Kamla-Balan, Kosi and Mahananda which finally drain into the river Ganga.

The total geographical area of north Bihar is approximately 52928 sq. km. comprising of 21 Districts namely Muzaffarpur, East Champaran, Sitamarhi, Seohar, Saharsa, Supaul, Darbhanga, Madhubani, Khagaria, Samastipur, Begusarai, Araria, Madhepura, Purnea, Katihar, Kishanganj, Saran, Gopalganj, West Champaran, Vaisali and Siwan,all of which are covered under the FMIS Focus Area.

The geographical area in south Bihar is approximately 41235 sq. km. comprising 17 districts namely Rohtas, Buxar, Kaimur, Bhojpur, Arwal, Patna, Jahanabad, Aurangabad, Gaya, Nalanda, Sheikhpura, Nawada, Lakhisarai, Munger, Jamui, Bhagalpur and Banka. Some major rivers lying within this region are Sone, Punpun, Kiul etc. Besides, there are many small rivers in this region also. However out of 17, only 3 districts viz Patna, Munger and Bhagalpur are covered under the FMIS Focus Area.

The soil of Focus area is sandy alluvial, rich in lime and often contains high proportion of clay. There are pockets where soils are calcareous with high proportion of calcium carbonate. The soils are among the most fertile in India and can support a variety of crops with appropriate land and water management.

2.3 Climate and Rainfall

Bihar 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 8^0C to 10^0C and maximum of 24^0C to 25^0C. The temperatures in the hottest months of April to June are minima 23^0C to 25^0C and maxima 35^0C to 38^0C.

The mean annual rainfall for the State is about 1270 mm varying from 1170 to 1580 mm in 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.

2.4 River System of Bihar

2.4.1 North Bihar

Important Rivers namely Ghaghra, Gandak, Burhi Gandak, Kosi and Mahananda etc. fall into river Ganga, the master drain flowing from west to east, whereas Bagmati- Adhwara, Kamla-Balan etc. drain into the Ganga through the Kosi.

The Ghaghra, Gandak and Burhi Gandak rivers of North Bihar are now more or less stabilized. It is believed that river Gandak has travelled from near Burhi Gandak on the east to its present course on the west in course of last several hundred years. In this process of shifting, it has created numerous "chaurs" (saucer like depressions) and "mauns" (deep horse-shoe shaped water bodies formed due to avulsions/cut-offs) in the Basin. The other North Bihar rivers such as the Bagmati, Adhwara group of river, Kamla-Balan and Kosi are still very unstable due to steep slopes in their upper reaches and high silt charges and are always exerting tremendous pressure on the embankments within which they are presently contained at enormous cost and efforts. The Kosi river is known to have shifted from near Purnea on the east to its present course on the west before it was embanked. However, this river tried to

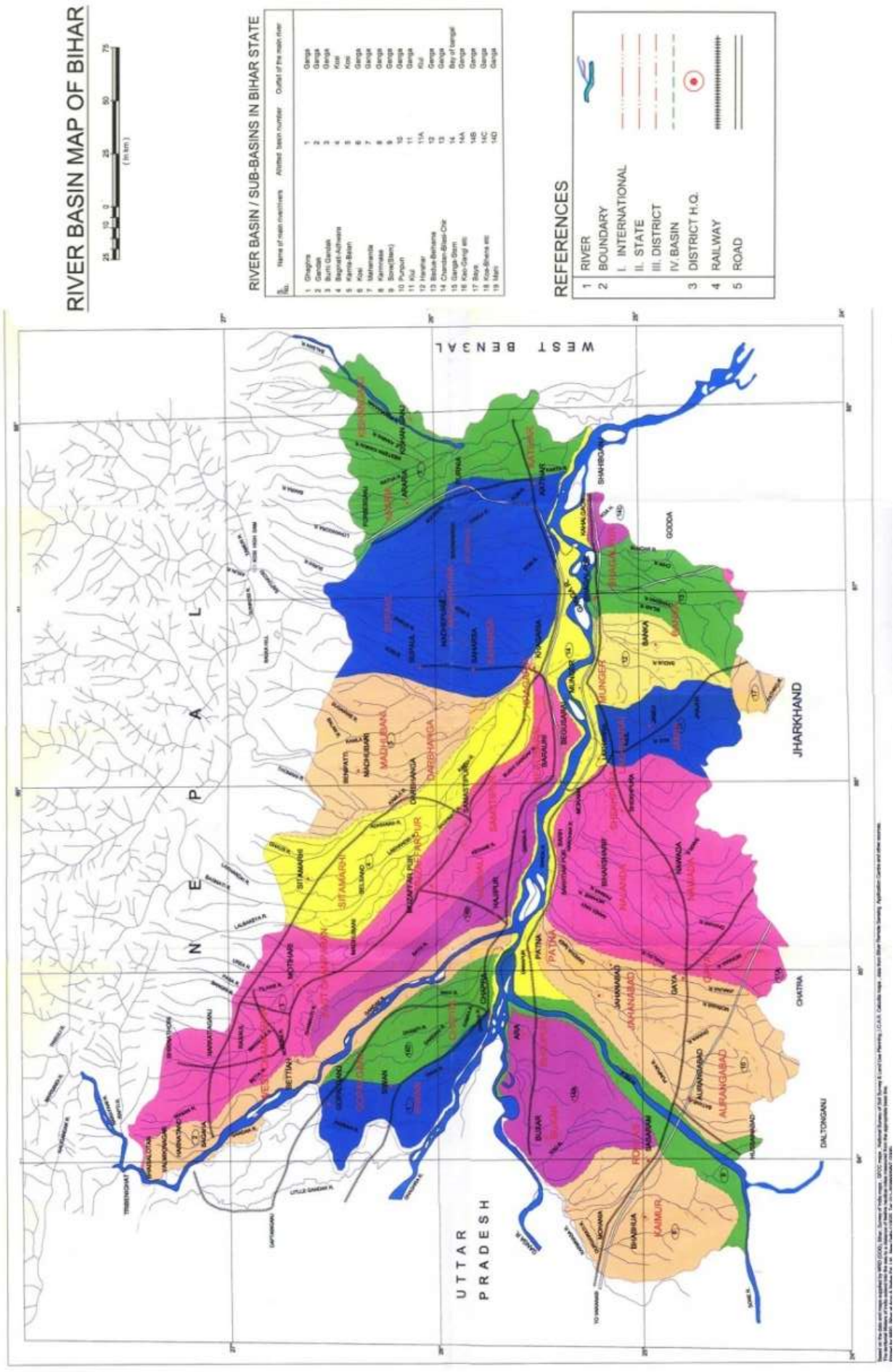
move towards east from its present course after the Kusaha (Nepal) breach in Aug 2008 but was brought back to its present course in Jan 2009 by adopting suitable measures. In its lateral travel of about 120 km. in course of about two centuries, the Kosi has created a number of swamps and marshy lands in the basin, apart from depositing coarse silt and sand in almost the entire area.

All the major rivers of north Bihar have Himalayan origin and considerable portion of their catchments lie in the glacial region. They are, therefore, snow-fed and perennial in flow. These rivers have catchments in the Himalayan region in Nepal. Some of them have catchments even in Tibet. They receive very copious rainfall during monsoon when discharges of these rivers are 50 to 90 times larger than fair weather flows. This causes frequent flooding of a large portion of north Bihar.

2.4.2 South Bihar

This tract of land is drained mainly by Rivers which are rainfed, having their origins either in the Vindhyachal hills or in the hills of Chhotanagpur and Rajmahal. These rivers are either dry or carry scanty discharges in non-monsoon months. Karmanasa, Sone, Punpun, Kiul, Badua, Chandan etc. are the important rivers of this region which fall ultimately into river Ganga.

A peculiar phenomenon in this region is the formation of Tal. The southern bank of the Ganga is naturally formed as a levee obstructing the drainage of the land on the south of it, which extends up to the foot of Chhotanagpur hills. The natural slope of this land is from south to north, i.e. from foot hills of the Chhotanagpur hills to Ganga. There are several rivers in this tract which drain the rain water of the tract and accumulate them behind the high bank of Ganga. This has resulted in formation of “tals” viz. Mokamagroup of Tals, the area just on the south of the high Ganga bank, which comprises of Fatuha Tal, Bakhtiyarpur Tal, Barh Tal, More Tal, Mokama Tal, Barahiya Tal and Singhaul Tal. These Tals also receive backwater of the Ganga when the latter is in high spate. Therefore, the Tals get submerged in water during monsoon season and thus most of the area is deprived from kharif cultivation. Even after the monsoon season, entire area does not get drained into the Ganga quickly. However bumper rabi and hot weather crops are grown in those Tal areas which get free from submergence on time.



Map - 2.2 River Basin Map of Bihar

2.5 Socio-Economic Profile

Bihar is one of the most populous state of India. It is growing at a very fast rate. High population below the poverty line requires a very high rate of GSDP. Unique social and economic situation of the state is a challenge for the development but it has taken off and soon will start to be enumerated with the developed states of the country.

2.5.1 Human development index indicator

Bihar

		2001	**2011(provisional)**
Per Capita income (in Rupees)		6850	20069
Literacy Rate		47.53%	63.82%
			(Male-73.39%, Female-53.33%)
Infant Mortality Rate	56(SRS 2008)		52
	60(SRS 2006)		

Source: Director of Statistics, GOB, Census report 2001/2011(provisional)

2.5.2 Agriculture

Bihar has a large alluvial river valley area. Against the backdrop of such generous natural resource in irrigation sector the overall percentage of net area irrigated in Bihar is about 73 % .

2.5.3 Demography

Bihar

	(2001)	**2011**
% Population in rural area	89.54	88.70
Density of population (per sq km)	881	1102

Source: Census report 2001, 2011(provisional)

2.6 Flood Typology

Conventionally, the typology of flood management classes is based on flood type, source area, warning time, flood duration and recession, and impact on agriculture. FMISC have identified 4 classes of floods which can be classified as

Class I: Flash floods – floods from Nepal rainfall, lead time is short (8 hours) in Kamla-Balan, recession is fast,

Class II: River floods – lead time 24 hours, recession is 1 week or more,

Class III: Drainage congestion in river confluence- lead time > 24 hours, lasting full rainy season, no Kharif cultivation,

Class IV: Permanent water logging - shrinkage in area only in Feb, local rainfall, micro-relief aspects.

Another classification which has been identified by FMIS resulted into four classes of Floods, which are following:

Not affected	<10% area inundated.
Low Flood	11%-30% area inundated.
Medium Flood	31%- 60% area inundated.
High Flood	> 60% area inundated

2.7 Occurrence of Floods in River Systems

A study has been done 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. Thereafter flood generally comes in River Burhi Gandak in the 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. In this flood period, Ganga was constantly high after mid July and reached the highest HFL in Bhagalpur after 1987.

2.7.1 Floods in Last Twelve 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 the pressures of industrial activities and other development works in the flood plains were 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 has 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's Annual Flood Report in chronological order during (2000-2011) is given as follows:

2000- Bagmati left embankment at chain 273 near village Madhkaul was cut by villagers. Chain 311 near village Madar was breached on 6/8/2000. Again in the last week of September and first week of October at km 11, 12, 20, 35.5 and 48 were cut by the villager. Incident of embankment cut have been reported earlier also. This was done to bring silt to raise land by the villagers. Kamla-Balan and Bhuthi-Balan catchments received heavy rainfall during first and last week of July resulting in unexpected rise of water. Slope of Left

embankment of Kamla-Balan embankment between km 89-90 in a length of 200 m was damaged. Spur at 2.80 km of Eastern Kosi Afflux Bund was punctured in the night of 4/8/2000 in a length of 20 m and the nose was washed away due to heavy pressure of river. A new nose and Shank was constructed in a length of 563 m and spur was made safe. The spur at km 14.5 was also damaged in half of its length in the night of 29/9/2000, expert from head quarter camped at the site and brought under control. Sikarhata Majhari Bund of western Kosi embankment between Km 6-7 was damaged in the night of 13/8/2000 but saved by doing flood fighting work. Heavy pressure on Spur at km 78.30 of Eastern Kosi embankment was overcome by undertaking flood fighting work.

2001-Left bank of river Burhi Gandak at Rampurwa Pulwar, Pakridayal, Enarwa Ghat, Mainpurwa and right embankment at Bihkhiya, Chakarniya, Bairiya, Koral, and Balochak was experiencing pressure but was saved by timely flood fighting. Burhi Gandak left embankment at 69-70 km at village More, the bed wall which was earlier constructed, damaged due to heavy local rainfall and pressure over embankment. Burhi Gandak at right embankment at 98-99 km at village Phulwaria anti-social element cut the embankment on 17.9.2001. The Right embankment of Bagmati River at Kothia and Surgahi and at left embankment at Kansar embankments were experiencing heavy pressure throughout the entire flood season but were saved by timely flood fighting. No breach in this reach occurred. Western Kosi embankment at Ghoghardiha, Jamalpur embankment at 30.105 km and at Sikhta Manjhari, there were pressure over embankment which was safely overcome by timely flood fighting. Western Kosi embankment at 2.25 km, the D-part of spur nose was damaged. Bhuthi-Balan right embankment breached due to overtopping at 20.91 Km, 21.01 km, 21.4 km 22 km, and 60.7 km in first week of October.

2002-Kamla-Balan left embankment at km 81.20 (Bugras) was cut by villagers in a length of 30 m which increased to 50 m. Overtopping reported in Kamla-Balan left embankment at km 38 at Bhadhuar on 23.7.2002, at 39 km near Bhadhuar sluice, at 50.5 km near Pipraghat, 51 km at junction point of rail cum road bridge and embankment and 74.8 km in Asma village on 23.07.02. Kamla-Balan right embankment at km 37 near village Banaur and km 64 at village Thengha were cut by villagers, piping and by anti-social elements in a length of 30 m which increased to 300 m. Bagmati right afflux bank embankment at ch. 1025 near village Dharampur was cut by the villagers on 23.7.02. Bagmati left embankment near ch. 145 of Sirsia ring bund at 20 to 30 ch. and 29 to 32.5 ch. the embankment was breached due to overtopping. Bagmati left embankment between ch. 145 to 149 was cut by villagers on 23.7 02. Kiroi left embankment at 7 km at village Masartharia and 5.25 km near Maasma and Kiroi right embankment at 12 km near Belwara Milki village and at 3 km near Bagwasa village, it breached due to overtopping on 24.7.02. Western Kosi embankment at 29 to 30 km below Kasba Bharda was cut by villages at 2 places.

2003- Maximum discharge of 389000 cusec passed through river Kosi where as discharge in excess of 250000 cusecs passed four times which resulted in continuous pressure on spurs/embankments. This resulted into damage of spurs in western Kosi embankment at 25.57, 15.80 and 15.30 km. On 1/8/2003 due to high discharge through the river, right embankment of Bagmati river at Surgahi site at chain 112-123 breached in 50 ft. which increased to 1100-2000 ft. On 1/8/2003 anti-social elements cut Kamla-Balan right embankment at km 66.50 in a length of 50 ft. Status of flood in other rivers except Ganga and Gandak remain normal. In river Ganga, the HFL at Bhagalpur surpassed the 1978 record of 34.18m and was at 34.20m level and at Patna at Ghandhi Ghat, the HFL level of 1994 (50.27m) was observed as against 50.12m in 2003. This heavy flooding in Ganga resulted in damage to the road network in Samastipur district. In river Gandak the maximum discharge 6,69,750 cusecs passed through Valmikinagar barrage on 31.7.03

2004- 2004 flood in the state of Bihar was unprecedented in many respects which proved to be very grave and damaging. Catchments area of North Bihar rivers received heavy rainfall in the first week of July itself which not only broke last three years' flood record but also surpassed the 1987 flood year which was the maximum flood producing year. Flood level at Dubbadhar site on river Bagmati surpassed all time high flood level by about 1.18 m. Similarly Burhi Gandak river on 15.7.04 and Kamla-Balan river on 10.7.04 touched all time high flood level. This itself speaks about the fury of flood in year 2004. Many places in the embankment of north Bihar were breached resulting in flood inundation in a vast area of north Bihar area. Unprecedented flood in river Bagmati, Burhi Gandak, Kamla and Bhuthi-Balan and Adhwara groups of river breached the embankments at many places and there was loss of life and property in a large scale. In river Kosi, situation was by and large normal and a maximum discharge of 286375 cusecs passed safely on 10.7.04.

2005 – The flood situation during 2005 was normal in comparison to the devastating flood of 2004. There were 63 numbers of breaches during 2004 flood, but only 8 breaches occurred during the year resulting in flood inundation in Madhubani and Katihar districts only. Left and right embankment of Kamla was breached at seven places during this year. Bhuthi Balan left embankment at km 21.22 and 22.80 was cut by the anti-social elements and due to flash flood, embankment was damaged at few places.

2006- The flood situation during 2006 was normal. There was 63 numbers of breaches during 2004 flood, this year only 1 breach occurred. Left embankment of Kamla was breached near village Asma at km 75.70 by anti-social elements but fortunately there was no loss of life or property. Flood situation in other places remained normal by and large.

2007- 2007 floods will be remembered for high degree of rainfall which was even more than the year 2004 flood. Districts of West Champaran, East Champaran, Gopalganj, Siwan, Madhubani, Darbhanga, Muzaffarpur, Samastipur, bore the fury of flood to a large extent. But fortunately compared to 2004 floods, there were fewer number of breaches (32 nos. in Bihar) in 2007 as compared to 63 in year 2004. Unprecedented flood in river Bagmati, Burhi Gandak, Kamala and Bhuthi-Balan and Adhwara groups of river breached the embankments at many places and there was loss of life and property. In the river Kosi, situation was by and large remained normal.

2008- There was an unprecedented flood due to a breach near 12.9 km of Eastern Kosi Afflux Embankment near Kushha village in Nepal on 18th August 2008 which very soon took the shape of a catastrophe leading to the misery of lakhs of people in Sunsari and Saptari districts of Nepal, and Supaul, Madhepura, Araria, Saharsa, Katihar and Purnia districts of Bihar. River Kosi entirely changed its course. This was tamed to its earlier course by WRD after tremendous efforts keeping in line with the advice of Kosi Breach Closure Advisory Committee (KBCAT).

2009-The floods in this year remained normal except few breaches such as Tilak Tajpur on right embankment of river Bagmati under Runnisaidpur block of Sitamarhi District, Gobindpur site of Labha Choukia Paharpur embankment of Mahananda river and Sallehpur Tandeshpur site of Gandak river. The loss to life and property was brought to minimum by undertaking rescue and relief measures.

2010- The flood situation this year remained quite normal with normal average rainfall. Only a few cases of breaches were reported viz. eastern Kosi Afflux Bundh and Saran

Embankment in a length of 200 m between 122.75 km and 122.95 km near Simaria village both due to sharp change in the river course.

2011-The flood situation remained normal with a few exceptions such as damage of nose of spur no-9 between Ismailpur and Bindtoli and that of revetment in 30 m length near Kazikoria of Raghopur village u/s of Vikramshila Setu and at spur no-9 and spur no-7 in a length of 138 m and 65 m respectively in d/s of Vikramshila Setu under Gopalpur block of Bhagalpur district, both on left embankment of river Ganga due to non-completion of anti-erosion work on time. Damages were also reported in Pataraha Chharki and P. D. ring bundh in Gopalganj district under Chief Engineer, Siwan jurisdiction. It is worth mentioning that water level attained by river Ganga at Bhagalpur this year was recorded as 34.17 m on 19.08.2011 against the water level of 33.26 m recorded last year on 03.09.2010. There was unprecedented flood in river Sone also with a max^{m} discharge of 9,58,000 cusecs on 25.9.11 at Indrapuri Barrage whereas the same was 61,130 cusec last year on 14.7.10.

2.8 Flood Characteristics of Focus Area

FMIS Phase-I focus area comprised of eleven districts of north Bihar in the first phase namely Muzaffarpur, Sitamarhi, Sheohar, East Champaran, Madhubani, Darbhanga, Samastipur, Begusarai, Khagaria, Saharsa, and Supaul. FMIS Phase-II focus area comprises of all districts of FMIS Phase-I; rest ten districts of north Bihar namely W. Champaran, Gopalganj, Siwan, Saran, Vaishali, Madhepura, Araria, Kishanganj, Purnea and Katihar and three districts of south Bihar namely Bhagalpur, Munger and Patna. A study has been done with the help of data obtained from DMD, Patna to see the flood events that took place in the development blocks of these districts in terms of inundation during 1987 to 2011 (25 years). A summary of the findings is given below:-

Sl No	Name of Districts	Number of Blocks affected out of last 25Years (1987 to 2011)			
		16Years and more	11Years – 15 Years	6Years – 10 Years	1Years – 5 Years
FMIS Phase-I Focus Area					
1	Muzaffarpur	5	3	2	6
2	Sitamarhi	6	6	6	0
3	Sheohar	1	2	1	1
4	East Champaran	-	10	9	9
5	Madhubani	2	8	9	5
6	Darbhanga	6	6	6	2
7	Samastipur	3	3	6	10
8	Begusarai	-	3	4	9
9	Khagaria	6	1	-	-
10	Saharsa	5	1	-	3
11	Supaul	5	1	1	5
Total of FMIS Phase-I Focus Area		39	44	44	50
Additional Area of FMIS Phase-II					
12	W. Champaran	3	4	8	3
13	Gopalganj	3	2	-	9
14	Siwan	-	-	-	15
15	Saran	-	2	6	10
16	Vaishali	-	3	3	10
17	Madhepura	2	-	6	4
18	Araria	1	7	1	-
19	Kishanganj	-	4	3	-
20	Purnea	3	1	5	4
21	Katihar	5	5	6	2
22	Bhagalpur	5	6	5	-
23	Munger	-	-	4	5
24	Patna	2	3	8	9
Sub Total		24	37	55	71
Total of FMIS Phase-II Focus Area		**63**	**81**	**99**	**121**
Rest Districts of Bihar					
25	Nalanda	-	-	9	11
26	Gaya	-	-	-	-
27	Nawada	-	-	-	-
28	Aurangabad	-	-	-	-
29	Jehanabad	-	-	-	-
30	Arwal	-	-	-	-
31	Bhojpur	-	2	4	8
32	Buxar	-	-	-	9
33	Rohtas	-	-	-	-
34	Bhabhua	-	-	-	-
35	Lakhisarai	-	-	-	-
36	Sheikhpura	-	-	-	-
37	Jamui	-	-	-	-
38	Banka	-	-	-	-
Sub Total		-	2	13	28
Total for Whole Bihar		**63**	**83**	**112**	**149**

(Source: Disaster Management Department, Bihar)

The table indicates that out of 364 blocks in FMIS Phase-II focus area, there are as many as 63 blocks that are most chronically flood affected and 81 blocks are chronically flood affected in terms of no. of times they were affected by floods in last 25 years.

2.9 Loss of Public Property since year 2000

Loss of Public Property

Year	Number of Affected									Crop Damaged (Rs Lac)	House Damaged		Public Property Damaged (in Rs. Lac)	Deaths	
	District	Blocks	Village	(in Lac)		Area (in Lac ha.)					Total	Value (in Rs. Lac)		Human	Animal
				Human	Animal	Agric	Non- Agric	Total	Cropped						
2011(P)	24	154	3588	64.171	5.98	2.642	0.639	3.001	1.279	5,627.00	28,067	12874.10	3578.6	143	33
2010(P)	8	41	489	7.22	0.56	0.631	1.112	1.743	0.03	202.45	8,733	479.26	59.2	28	2
2009	16	91	1546	22.03	1.346	1.71	9.339	11.05	0.475	2182.57	7674	528.15	530.10	97	2
2008	18	116	2585	49.952	12.166	6.405	2.12	8.824	3.672	3420.25	297916	8451.40	9771.96	258	878
2007	22	269	18832	244.42	27.13	13.323	5.51	18.833	10.603	7683782	784328	83144.52	64241.52	1287	2423
2006	14	63	959	10.89	0.1	1.52	0.297	1.81	0.87	706.63	18,637	1,225.03	8,456.17	36	31
2005	12	81	1,464	21.04	5.35	3.343	1.261	4.6	1.35	1,164.50	5,538	382.79	305	58	4
2004	20	211	9,346	212.99	86.86	20.99	6.01	27.00	13.99	52,205.64	9,29,773	75,809.51	1,03,049.60	885	3272
2003	24	172	5,077	76.02	11.96	9.943	5.14	15.08	6.10	6,266.13	45,262	2,032.10	1,035.16	251	108
2002	25	6	8,318	160.18	52.51	14.45	5.244	19.69	9.4	51,149.61	419,014	52,621.51	40,892.19	489	1450
2001	22	194	6,405	90.91	11.7	9.042	2.91	11.95	6.5	26,721.79	222,074	17,358.44	18,353.78	231	565
2000	33	213	12,351	90.18	8.09	6.57	1.476	8.05	4.43	8,303.70	343,091	20,933.82	3,780.66	336	2568

Source: (Disaster Management Department, Bihar website: http://www.disastermgmt.bih.nic.in/) & Provisional figures based on Form-IX dated 15.10.2010 and 15.10.2011.

2.10 District-Wise Damage Statistics for Flood – 2011

District-wise flood damage statistics as obtained from DMD for flood 2011 for Phase-II Focus area and rest area of Bihar is given below:-

Sl. No.	District	Number of Affected Blocks	Nos. of Affected village	Cropped Area (Lakh hect.)	Estd. Crop damage (Rs. Lac)	No. of houses/ huts damaged (Fully /Partially)						Estimate d Value of house damage In (Rs. Lac)	Public Properties damage (Rs. Lac)	Live Lost (Nos)		
						Pucca (F)	Pucca (P)	Kachcha (F)	Kachcha(P)	Huts	Total			Human		Animal
														Flood	Others	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
FMIS Phase-I Area (11 Districts)																
1.	Muzaffarpur	06	187	-	-	0	0	95	15	0	110			12	-	-
2.	Sitamarhi	17	780	-	-	0	0	10	12	22	44	-	500.00	14	-	-
3.	Sheohar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.	E.Champaran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.	Madhubani	15	185	0.14	-	-	-	785	916	11216	12917	11216	0.95	07	-	1
6.	Darbhanga	06	343	-	-	-	-	24	13	117	154	-	-	28	-	-
7.	Samastipur	06	177	0.1	-	-	-	-	-	-	0	2.00	514.50	05	-	1
8.	Begusarai	08	131	-	-	-	-	11	45	47	103	-	42.5	09	-	2
9.	Khagaria	03	59	-	-	-	-	-	-	-	0	-	-	06	-	-
10.	Saharsa	07	30	-	-	-	-	24	-	1228	1252	26.96	2.50	10	-	-
11.	Supaul	05	94	0.08	181.00	-	-	-	-	2159	2159	143.14	-	01	-	-
Total for FMIS Phase-I Area (11 Dstricts)		**73**	**1986**	**0.32**	**181.00**	**0**	**0**	**949**	**1001**	**14789**	**16739**	**11388.1**	**1060.45**	**92**	**0**	**4**
Additional area in FMIS Phase-II (13 Districts)						-	-	-	-	-						
12.	W. Champaran	05	20	-	-	-	-	808	-		808	-	-	4	-	-
13.	Gopalganj	01	21	-	-	-	-	-	-		-	-	-	2	-	-
14.	Siwan	-	-	-	-	-	-	-	-		-	-	-	-	-	-
15.	Saran	06	169	-	-	-	-	-	-	86	86	1.00	-	-	-	-
16.	Vaishali	06	104	0.08	7.5	-	-	-	12	-	12	1.00	-	4	-	-
17.	Madhepura	05	47	0.021	21.5	5	25	65	50	368	513	950.00	11.00	3	-	-
18.	Araria	02	13	-	-	-	-	31	-	-	31	8.45	-	-	-	-
19.	Kishanganj	01	2	-	-	-	-	-	-	-	-	-	-	-	-	-
20.	Purnea	06	54	-	-	7	-	680	-	-	687	79.25	-	1	-	-
21.	Katihar	04	235	0.29	56.00	-	-	-	-	-	-	3.5	-	2	-	-
22.	Bhagalpur	15	339	0.20	846.45	238	172	1079	1328	1328	4145	53.06	42.50	14	-	25
23.	Munger	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24.	Patna	13	230	0.15	-	-	-	-	-	-	-	-	-	1	-	-
Sub Total		**64**	**1234**	**0.741**	**931.45**	**250**	**197**	**2663**	**1390**	**1782**	**6282**	**1096.26**	**53.50**	**31**	**0**	**25**
Total for FMIS Phase-II Focus Area (24 Districts)		**137**	**3220**	**1.061**	**1112.45**	**250**	**197**	**3612**	**2391**	**16571**	**23021**	**12484.36**	**1113.95**	**123**	**0**	**29**

Additional area to be covered in FMIS Phase-III (14 Districts)																
25.	Nalanda	04	104	0.008	-	-	-	-	-	-	-	-	-	-	-	-
26.	Gaya	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27.	Nawada	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28.	Aurangabad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29.	Jehanabad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30.	Arwal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31.	Bhojpur	06	210	0.16	4419	-	-	1242	3754	-	4996	388.24	2501.00	12	-	1
32.	Buxar	04	12	-	-	-	-	-	-	-	-	-	-	-	-	-
33.	Rohtas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34.	Bhabhua	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35.	Lakhisarai	03	42	0.05	95.5	-	-	2	8	40	50	1.54	6.00	8	-	3
36.	Sheikhpura	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37.	Jamui	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38.	Banka	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sub Total		**17**	**368**	**0.218**	**4514.5**	**0**	**0**	**1244**	**3762**	**40**	**5046**	**389.78**	**2507.00**	**20**	**0**	**4**
Grand Total (For Whole Bihar)		**154**	**3588**	**1.279**	**5626.95**	**250**	**197**	**4856**	**6153**	**16611**	**28067**	**12874.14**	**3620.95**	**143**	**0**	**33**

(Source: Disaster Management Department, Bihar, Patna(Cumulative Form-IX dated 15.10.2011)**)**

3.0 AIMS AND ACTIVITIES OF FMISC

3.1 Aims

The Government of Bihar has identified improvement in flood control as a priority area for World Bank engagement in the State. The World Bank – Government of Bihar Partnership Matrix (2006) prioritizes the improvement of the institutional capacity for delivering better flood management and drainage services, as a key action for accelerating agriculture productivity in North Bihar. The **Flood Management Information System (FMIS**), identified for entry-level and short-term bank engagement in Bihar, is designed to generate and disseminate timely and customized information to move the sector agencies from disaster response to improved disaster preparedness and to effectively support flood control and management in the flood prone areas of the State of Bihar. Improved flood management that will protect the poorest farmers located in the low value lands in the flood plains, is also in line with the Bank/DFID partnership policy of extending Bank's support to state reforms that could lead to lasting poverty reduction.

The development of FMIS is planned in four stages: Flood hazard characterization & emergency response; improved flood preparedness and community participation; Flood hazard mitigation**;** and Integrated flood management. The technical improvements in flood forecasting, inundation modeling and warning, and embankment management are also coupled with expanded institutional and community linkages and expanding geographic coverage (from the most flood-prone 11 districts in north Bihar in the first stage to the whole flood prone area in the third stage). The fourth stage aims to develop integrated flood/drainage/irrigation management through upgrading FMIS into a Water Resources Information System, implementing operational community based flood management and operationalizing regional flood knowledge base and management plans.

The first module has been implemented and operational during 2007 flood season, with focus on flood hazard characterization and operational flood management information products, supplemented by improved flood forecast, a flood website for public dissemination and access, updated flood control manuals, plans for upgrading hydrologic measurements and telemetry, and training. Providing and disseminating information tools has moved sector agencies capacity from disaster response to improved disaster preparedness and to effectively support flood control and management in the flood prone areas of the State of Bihar. The FMIS in the first stage had covered the focus area from Burhi Gandak river in the west and Kosi river in the east in North Bihar that is most flood prone in the State.

The subsequent stages of FMIS development would cover substantially enhanced functions and products, supported by improved hydrologic observations and telemetry, more reliable and longer term rainfall forecasts, enhanced flood forecast and inundation prediction with better models, airborne Synthetic Aperture Radar (ASAR) surveys for real-time inundation information during floods, close-contour surveys of the flood plain, mapping flood plain geo-morphology including micro-relief to understand and improve drainage, improved communication links and information flow, risk and vulnerability analysis, institutional and community outreach mechanisms, and real-time flood data dissemination. The fully upgraded FMIS would support preparation of master plan for flood control and drainage, irrigation improvement, and overall water sector development in Bihar State.

3.2 FMIS Phase–I Objectives

FMIS Phase-I objectives were:

- To move from disaster response to improved disaster preparedness,
- To improve the lead time of the forecasts,
- Develop a focal point in an institutional (e.g. a multi-disciplinary Flood Management Information System Cell) framework
- Information (e.g. a web-portal for Bihar Flood Management) setting,
- Improved information flow (e.g. bulletins, improved use of email/internet/cell phones)
- Sector preparedness (by updating flood manuals).

Along with a substantive effort of planning the development and rehabilitation of the flood and drainage control infrastructure, in the short term, there is a compelling need for adopting new technological approaches to improve the decision process before, during and after the flood events and the use and allocation of available resources.

In the short-term FMIS would help to strengthen existing institutional capacity and arrangements for flood management in the state and make extensive use of modern technology (e.g. satellite remote sensing, Geographic Information System [GIS], Internet, forecast models, etc.). Relevant outcomes of the technical assistance are the strengthening of flood knowledge base and analysis, the dissemination and outreach of operational flood management information and the improvement of flood preparedness.

3.3 Activity Completion Report for Phase I

The project components included:

i) Development of FMIS
ii) Improved flood forecasting
iii) Bihar Flood Information Website
iv) Updated flood control manual
v) Training
vi) Plan for upgrading hydrologic measurements and telemetry.

The 'Activity Completion Report' received from the World Bank mentions that FMIS has already been set up. FMIS website has been developed and hosted. The website (http://fmis.bih.nic.in) is operational and providing public access to flood data. FMIS officers have been trained. The FMIS has addressed information needs for early warning and emergency response of three key Departments: Water Resources, Disaster Management Department and Agriculture Department. The Central and State Agencies linkages (linkage between WRD, GOB, and NRSA/ IMD / SOI/ CWC and GFCC) have been strengthened. In a nut shell, almost all the project activities of phase-I have been successfully completed and the project outputs and outcomes have been substantially realized with the disbursement to the tune of about 93 percent of the total project cost. The Bank has expressed its pleasure over the WRD's commitment for sustaining the FMIS by supporting continued operation with substantial augmentation of systems and staff.

3.4 Activities of FMISC in 2011

Like previous years, this year too, FMISC, Patna with all its resources and as per its mandate was ready and prepared for the flood season 2011. The satellite data for North Bihar, which were received in FMISC, Patna from NRSC, Hyderabad, were further processed, value added and disseminated almost same day or next day to the user/stakeholder departments like WRD, DMD, GFCC, Agriculture Department, NRSC, CWC etc.

3.4.1 Flood Control Centre at FMISC

Similar to previous years, FMISC was ready to face any emergency situation during flood. This year too FMISC geared up with its limited personnel and resources at its disposal and started collecting information, maps and satellite images from all possible sources : indigenous or global. The Centre started working in two shifts, from 7 a.m. to 2.00 p.m. and from 2 p.m. to 9 p.m. daily including holidays during flood period.

There was continuous liaison with CM Secretariat, Water Resources Department and Disaster Management Department and **value added maps** were provided as required in shortest possible time.

3.4.2 Information disseminated by FMIS Centre

3.4.2.1 Information provided to WRD

FMISC produced some useful maps in flood season 2011 based on the available satellite data and past years' experience. This year FMISC produced maps showing "points to be observed" where flood protection works were carried out after flood 2010. In most cases, latest satellite images showing pre-monsoon condition of Rivers were used as a backdrop. Locations of past years flood protection schemes were marked so that the concerned engineers could see the effect of Flood Protection works at those sites.

This season has been quite eventful with rivers of South Bihar in full action. In North Bihar, breaches were averted as we provided a "vigilant view" of river's action at fairly close interval. Some of the events and the action by FMISC are highlighted below-

1. The most important episode was related to Kosi River which has shifted markedly to the eastern side of the embanked portion. Observers from field kept on reporting about enhanced erosion between spurs located at 5.70, 9.25, 16, 18.53, 18.80 and 25.14 Km of Eastern Kosi Embankment. It was feared that the embankment may give way to mounting pressure and would cause immense damage to adjoining areas. The Government was very much concerned about the eventualities, therefore, FMISC was asked to generate maps showing probable inundation scenario in case of breach at these points. We produced maps with the help of available satellite images and the latest course of Rivers depicted from latest images. Layout of major civil infrastructure was also considered and finally 3 different scenarios were generated. These maps were extensively used for disaster preparedness and flood fighting works.
2. Similar maps were prepared for the same embankment which was constantly under threat between 80 and 81.75 km.
3. Kosi river kept on creating new threats all along its course. Embankment was under threat at Birbas where a pilot channel was dredged for modifying the flow of river. This was also monitored by field engineers using maps prepared by FMISC.
4. Many flood fighting works were done by WRD after flood 2010 in Gandak Embankments. It was very much important for the field engineers to keep a close vigil on such sites and other vulnerable sites. FMISC produced some maps showing latest flow pattern of Gandak River right from Valmikinagar Barrage to Hajipur. These maps were found very useful and many more maps were generated for specific sites like Koerpatti, Dhanaha, Patraha Chharki, and Bagaha town.
5. Alert maps were also prepared for Burhi Gandak Rivers and were distributed to concerned Chief engineers.

6. Ganga River was in spate since the beginning of monsoon as the rainfall pattern of this monsoon season was of extreme type. Western and central part of the country experienced heavy to very heavy rainfall which ultimately comes down to Ganga and passes through Bihar. The river was threatening at many places but Ismailpur-Bindtoli site below Vikramshila Setu at Bhagalpur was a real cause of concern. Constant erosion has eaten away a sizable portion of Spurs and land between spurs and had finally reached a position where embankment was under direct threat. FMISC provided up-to-date position of river with the help of satellite images acquired from various sources. These maps were used for planning as well as monitoring purposes.
7. The rainfall pattern of this season kept us on the toe almost round the clock. Adhwara rivers; which seldom caused big threat for last four year; suddenly became a centre of action this season. Multiple over-toppings were reported as the cyclonic development produced unprecedented deluge in Bihar as well as in Nepal Terai. This caused floods in Sitamarhi, Darbhanga, Muzaffarpur and Madhubani districts. FMISC produced regular inundation maps as well as maps showing spread and recede of water over a long period of time. Satellite images of multiple types and dates were used to show flood receding pattern.
8. A small breach was reported in Khairpur-Raghopur (Bhagalpur-Upstrem of Vikramshila Setu). FMISC was asked to produce a map showing probable areas of inundation.
9. Kosi Embankment in Nepal was reported to be under threat near 25 km of Eastern Afflux Bund. FMISC promptly acquired an image to show the real situation at the site under question. Images obtained at close interval helped to reduce the panic and also to plan action.
10. Normally, FMISC keeps itself centered on North Bihar events for which it has good amount of data but certain situations had pressed us hard to produce maps for areas which we usually do not cater. Sone river, which is a south Bihar river, posed a big threat this year due to extremely heavy rain fall in its catchment. As the river finally meets Ganga (itself in spate) near Patna, the threat was inevitable. FMISC produced a map showing the whole system causing threat. Higher officials used this map extensively for action as well as protection and relief operation.
11. This year FMISC's services were required more for monitoring of previously done Flood fighting works rather than recording and reporting flood events. Higher officials were busy in visiting threatened sites and FMISC provided all the requisite maps at short notice. CM's Seva Yatra also made full use of FMISC's products and services.
12. South Bihar experienced much better monsoon than normal this year which also caused flood in Punpun and Falgu Catchments. Chief Minister visited this area many times and made detailed observation assisted by Maps produced by FMISC. He also made repeated sorties over whole length of Ganga from Buxar to Kahalgaon. FMISC produced maps for this type of observation as well.
13. After monsoon, the Centre is regularly providing products and services for planning pre-2012 flood protection work.

3.4.2.2 Information provided to DMD

Satellite imageries were provided to DMD as and when asked for, which helped them in taking necessary rescue and rehabilitation measures.

3.4.3 Contribution of FMIS Centre to Technical Advisory Committee (TAC), WRD and GFCC in taking decisions for Anti-Erosion Works for Year 2011.

Like previous years, this year too, TAC took place at FMISC. Our specialists sat with the committee and showed maps showing changing behavior of major rivers of North Bihar like Gandak, Kosi, Kamla, Bagmati, Burhi Gandak and some stretches of Ganga. This value addition to our GIS data bank came handy in deciding Embankment maintenance and Anti-erosion works. All the schemes submitted by field officers to TAC were scrutinized with the help of these maps.

Nearly all large schemes, referred to GFCC for clearance, were aided by FMIS inputs in the form of latest satellite pictures overlaid with river positions of past 3 to 6 years. This helped a lot in technical decision making at State and High Level Committees. GFCC officers, before visiting Gandak and Kosi, interacted with FMISC specialists to get first hand report on changed behavior of the rivers after flood.

3.4.4 Capacity Building

A Workshop titled **"International Approaches to Manage and Plan Embankment Assets"** was organized by FMISC in collaboration with World Bank at Hotel Chanakya during 15-20 October 2011. Engineers at different level of our organization, posted in field at different Chief Engineer's zone and head quarter, participated in the workshop. Workshop was also well attended by retired engineers and Chairmen of the Flood Fighting Force. It came to the notice of participants that, in WRD, we have well maintained practice of periodic embankment inspection and maintenance of WRD embankments during flood season but we don't have regular periodic embankment inspection during non-flood season. It also came to the notice that we don't have any electronic mechanism of record keeping for the inspection and maintenance done. For two consecutive days, different points of inspection were discussed and a check list for embankment inspection was formulated. Then, at FMISC, A final draft of the check list was prepared and sent to all the chief engineers for their suggestion and approval. After getting their approval, their suggestions were incorporated.

3.4.5 e-bulletin

e-bulletins were issued and posted on FMIS website regularly during flood season. e-bulletin for the month of October 2011 is annexed (Annexure I).

4.0 FMIS website

URL :http://fmis.bih.nic.in

The FMISC website is an information dissemination interface of the FMISC. The presentation of the information is in text & graphical maps. Scenario have been analysed to develop a system which is purely graphical. The main motto of this project is to provide the user with a platform where they can get flood information related to any particular area.

Apart from a brief discussion about the technology used and the activities carried out by the FMISC, the site also provides detailed maps related to the flood inundation status, breach points on the embankments, inundation levels etc, of the area covering the focus area of FMIS Phase I comprising of 11 flood affected districts of North Bihar presently. It is, however, planned to extend it to focus area of FMIS Phase II comprising of 21 districts of North Bihar and 3 districts adjoining River Ganga in South Bihar, after completion of FMIS phase II.

FMIS website includes:

- ***Daily hydro-meteorological status*** of North Bihar, having DL (Danger level) WL (Water level) and RF (Rainfall) during the flood season i.e. 15th of June to 15th of October.
- ***Daily flood bulletins*** are issued every day during the flood season. These bulletin contain summarized information about the observed rainfall, water level and basin wise maximum forecasted rainfall for 3 days obtained from IMD.
- ***Inundation map*** for WRD and DMD, show aerial extent of flood water spread. The inundation extent is derived from RADARSAT Layers/Imagery provided by NRSC in processed 1 bit image format.
- ***Monthly E-Bulletin*** is published every month during flood season. This is an in house production and gives a brief account of activities of FMISC.
- ***End Season Flood Report*** is also published at the end of flood season.
- ***District level rainfall forecast of 5 days for Bihar and Jharkhand*** as obtained from IMD are included on daily basis during flood season.
- ***Important links, Photo Gallery, Weather widget are also included in the website.***

Some essential features of our websites are outlined below:

Construction

Website is built using the latest technologies and is highly optimized for speed so that viewers don't sit around waiting for pages to load, or even worse move on to another website.

Navigation

Clear and simple method of website navigation for the viewer is a primary aim. Variety of navigation systems including pull-down and pop-up menus has been implemented. Undertake trials and constant modification of the website to enhance the browsing experience is a regular ongoing work.

Future action

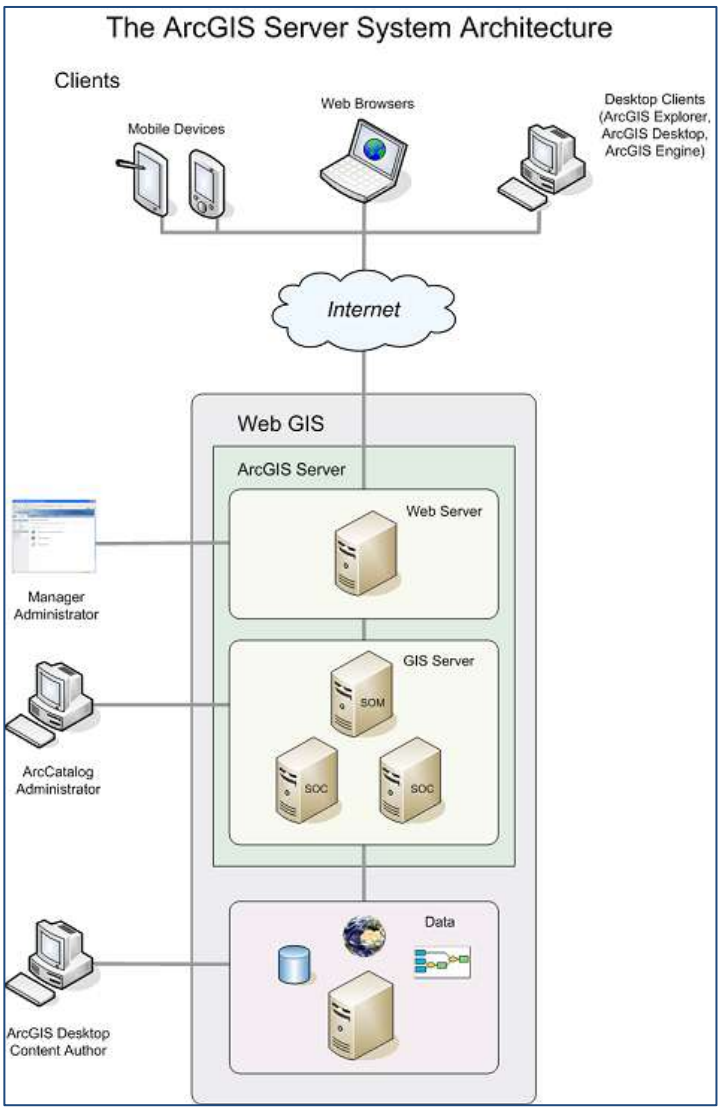
Over the years the website has silently but surely established itself as a media which introduces the users within and without, to the activities which are being carried out in the FMISC. With the number of stake holders rising every day, FMISC is trying its best to meet the myriad demands of Thematic maps and Imageries. Under these circumstances the website will have an important role in catering to increasing demands of customized maps and other information products. It is, therefore, mandatory to have a website that will allow the users to generate maps and other information product as per their needs.

The salient features of the future website will be:

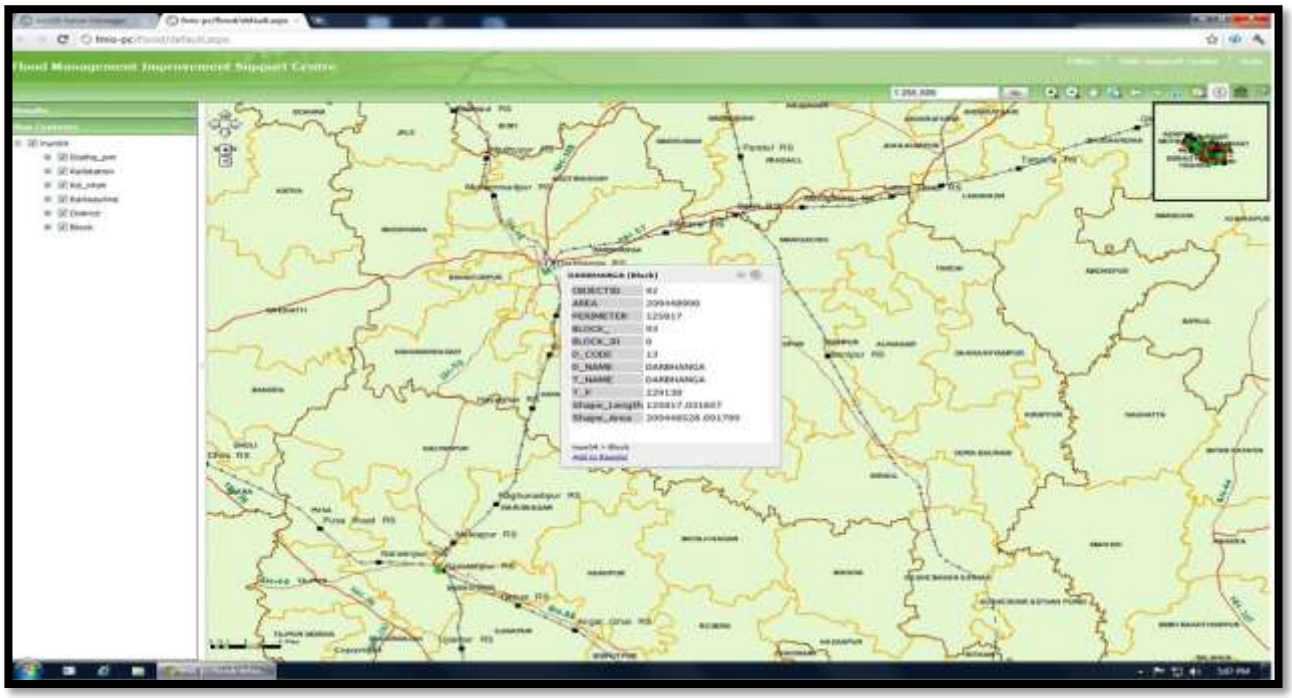
Interactive Map

- Working for an organization that manages geographic information, FMISC is facing with the challenge of sharing our collection of geographic information, with people inside this organization and those outside as well. For this challenge it has been decided to choose ArcGIS Server. ArcGIS Server provides the platform for sharing GIS resources, such as maps, with user community, whether they are sitting in the same office using ArcGIS Desktop or sitting across the World accessing and viewing maps through the Internet.

- Today, it is commonplace to see maps or other geographic information integrated seamlessly into Web sites. ArcGIS Server helps us to put geographic information on the Web, whether FMISC need an application that simply displays a map or a more sophisticated one that incorporates specialized GIS tools. Access to the GIS server is embedded inside the Web application and typically hidden from the user of the application.




fmisc
fmisc
Bihar
Flood Management Improvement Support Center
Today's Weather
Inundation Maps
Hydrometeorological Status
Event Related Maps
Statistics
Rain Forecast
Archives
Models
fmisc
Flood Management Improvement Support Center is a World Bank sponsored project under Water Resources Department, Govt. of Bihar. The comprehensive FMIS would be developed in four stages. In the first stage the focus area is the most flood prone area in North Bihar,from Burhi Gandak river in the west to Kosi river in the east, including the districts East Champaran, Muzaffarpur, Begusarai, Samastipur, Dharbanga, Saunarhi, Sheohar, Madhubani, Supaul, Saharsa, and Khagaria covering about 20,000 sq. km. in area
MORE...
Services
Important Links
Notices and Tenders
Request for Maps
Weather
News
Latest Inundation Status


Flood Management Improvement Support Centre

5.0 2011 Floods –Hydrologic analysis

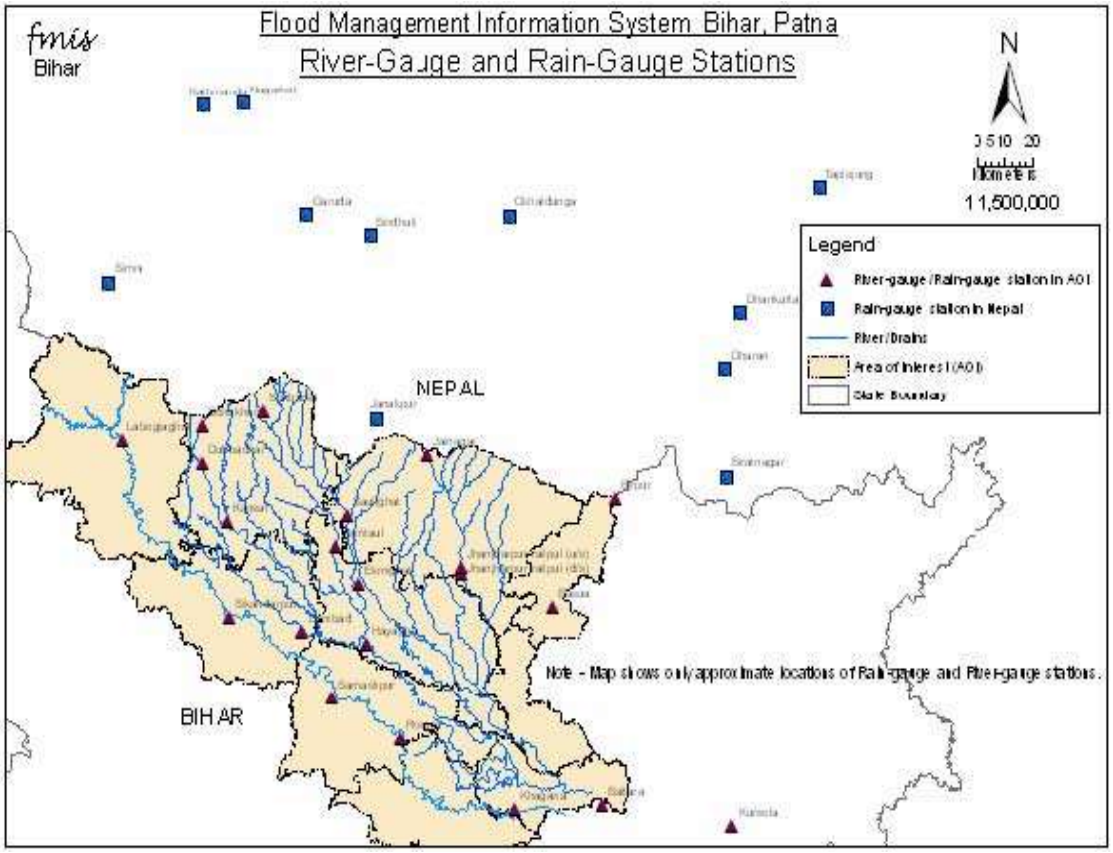
Area of interest (AoI) of Flood Management Improvement Support Centre, Bihar receives flood water from vast areas of Nepal through four main streams viz. Burhi Gandak, Bagmati, Kamla and Kosi. The FMIS Center received daily rainfall / river water level data of some stations falling in these basins whose details are as follows.

Sl. No.	Name of measuring station	Location		Maintained by	Type of data	Mode of data acquisition
		Basin/River	(Nepal/ Bihar)			
1	2	3	4	5	6	7
1	Simara	Burhi Gandak	Nepal	GON	Daily Rainfall	Web site2
2	Kathmandu	Bagmati	Nepal	GON	Daily Rainfall	Web site2
3	Nagarkot	Bagmati	Nepal	GON	Daily Rainfall	Web site2
4	Garuda	Bagmati	Nepal	GON	Daily Rainfall	Telephone3
5	Janakpur	Kamla	Nepal	GON	Daily Rainfall	Web site2
6	Sindhuli	Kamla	Nepal	GON	Daily Rainfall	Telephone3
7	Okhaldunga	Kosi	Nepal	GON	Daily Rainfall	Web site2
8	Taplejang	Kosi	Nepal	GON	Daily Rainfall	Web site2
9	Dhankutta	Kosi	Nepal	GoN	Daily Rainfall	Web site2
10	Biratnagar	Kosi	Nepal	GoN	Daily Rainfall	Web site2
11	Dharan	Kosi	Nepal	GoN	Daily Rainfall	Web site2
12	Lalbegiaghat	Burhi Gandak	Bihar	CWC, GoI	DRF& RS1	Email4
13	Sikandarpur	Burhi Gandak	Bihar	CWC, GoI	DRF& RS1	Email4
14	Samastipur	Burhi Gandak	Bihar	CWC, GoI	DRF& RS1	Email4
15	Rosera	Burhi Gandak	Bihar	CWC, GoI	DRF& RS1	Email4
16	Khagaria	Burhi Gandak	Bihar	CWC, GoI	DRF& RS1	Email4
17	Sonakhan	Bagmati	Bihar	WRD, GoB	River Stage	Flood News5
18	Dubbadhar	Bagmati	Bihar	WRD, GoB	River Stage	Flood News5
19	Kansar	Bagmati	Bihar	WRD, GoB	River Stage	Flood News5
20	Benibad	Bagmati	Bihar	CWC, GoI	DRF& RS1	Email4
21	Hayaghat	Bagmati	Bihar	CWC, GoI	DRF& RS1	Email4
22	Kamtaul	Bagmati/Khiroi	Bihar	CWC, GoI	DRF& RS1	Email4
23	Sonbarsa	Bagmati/Khiroi	Bihar	CWC, GoI	DRF& RS1	Flood News5
24	Saulighat	Bagmati/ DarbhangaBagmati	Bihar	CWC, GoI	DRF& RS1	Flood News5
25	Ekmighat	Bagmati/ DarbhangaBagmati	Bihar	CWC, GoI	River Stage	Email4
26	Jainagar	Kamla	Bihar	WRD, GoB	River Stage	Flood News5

27	Jhanjharpurrailpul (u/s)	Kamla	Bihar	WRD, GoB	River Stage	Flood News5
28	Jhanjharpurrailpul (d/s)	Kamla	Bihar	CWC, GoI	DRF& RS1	Email4
29	Basua	Kosi	Bihar	CWC, GoI	DRF& RS1	Email4
30	Baltara	Kosi	Bihar	CWC, GoI	DRF& RS1	Email4
31	Kursela	Kosi	Bihar	CWC, GoI	DRF& RS1	Email4
32	Birpur	Kosi	Bihar	CWC, GoI	DRF& RS1	Flood News5

1 Daily Rainfall and River stage, 2 www.mfd.gov.np, 3 from CWC, 4 from CWC, 5 Daily Flood News of Water Resources Dept. GOB

Location of the above stations is depicted in the map below.



Map 5.1.1 – River-Gauge and Rain-Gauge Stations

5.1 Rainfall

The monsoon has been good this year after two successive years of partial draught. According to the report of IMD, the total rainfall from 1st June to 15th October 2011 has been 1060 mm which is only 1.45% less than normal rainfall. This has definitely given a sigh of relief in the agriculture sector. We may hope good kharif as well as rabi crops this year.

The following Table compiles monthly / monsoon rainfall as well as number of rainy days observed at different stations falling in the concerned basins. This compilation is based

on the daily rainfall data received from local Division of Central Water Commission and the Nepal website www.mfd.gov.np.

If we look at the Table below, we observe that monthly rainfall in Nepal as well as Bihar at various stations in different basins at various stations in different basins has been appreciable. All stations except Nagarkot in Nepal and Jai Nagar in Bihar had rainfall on more than 50 days in this monsoon period. Kathmandu had the maximum 94 days of rainfall of the total of 122 days of rainfall (from 15th June to 15th October). The next two stations were Taplejang in Nepal and Kursela in Bihar having 84 days of rainfall. If we compare this monsoon rainfall with the Normal Monsoon Rainfall, it reveals that the monsoon in Nepal has been well below normal this year almost on all stations. Monsoon, however, this year in Bihar, has been more or less equal to normal rainfall at almost all stations.

July has been the wettest month followed by September, August, June and October in that order.

A word of caution 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.

Isohyet maps showing the contours drawn with the rainfall figures available with us are also given below. The June rainfall is taken from 15th of the month and the October rainfall is only up to 15th of the month.

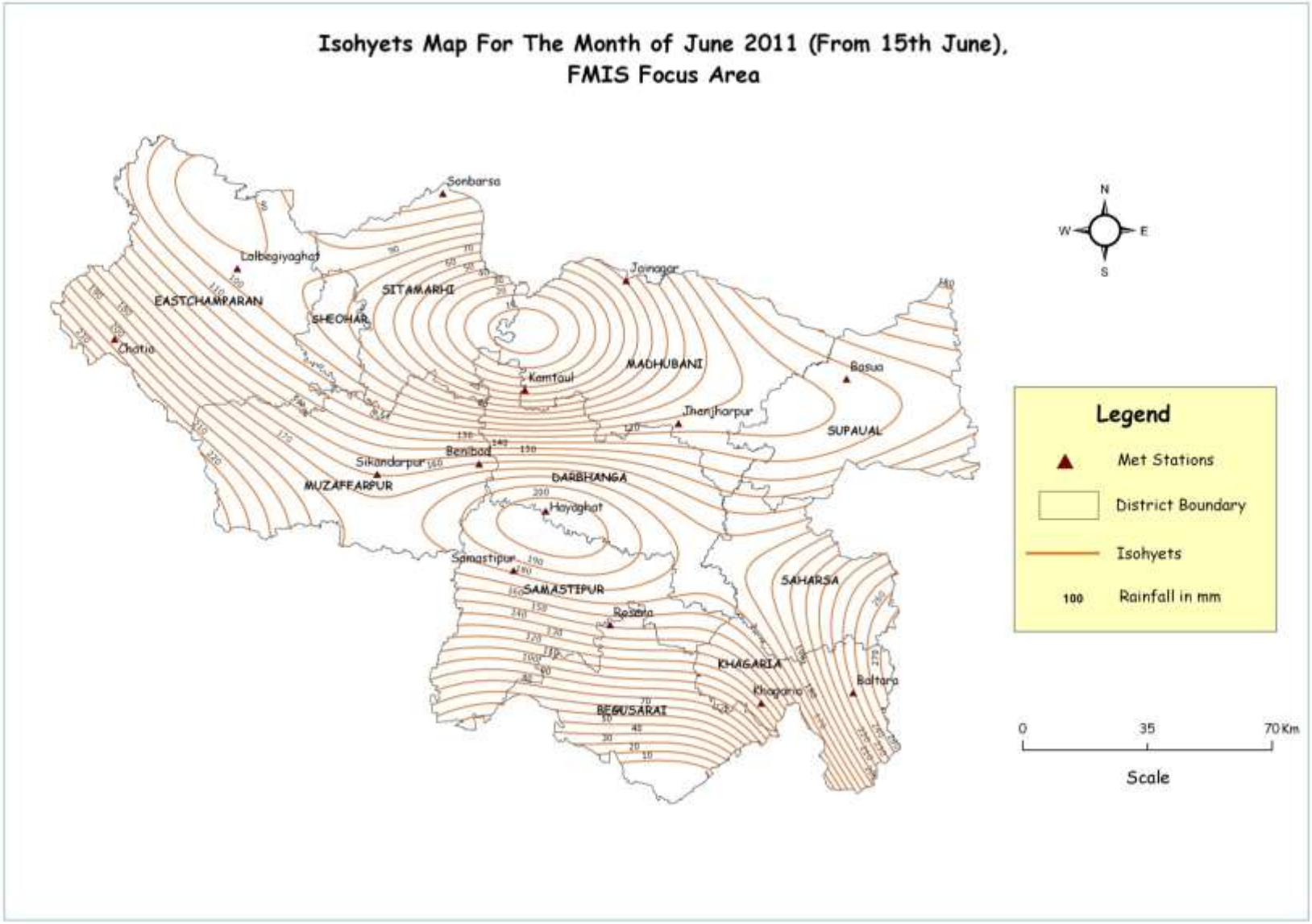
Monthly Monsoon Rainfall (mm) observed in the river basins of AoI-Flood 2011									
River Basins	Rain Gauge stations	Monthly Rainfall					Monsoon 2011		Normal Monsoon Rainfall
		June (from 15 June)	July	August	September	October (up to 15 Oct)	Total	No. of Rainy days	
1	2	3	4	5	6	7	8	9	10
BurhiGandak	*Simra*	131.9	655.1	370.8	175.3	0	**1333.1**	53	1497.4
	Lalbegiaghat	93.9	429.3	198.5	366	0	**1087.7**	55	
	Sikandarpur	159.3	374.2	226	471.6	0	**1231.1**	55	
	Samastipur	182.6	244	292.3	117.2	7.4	**843.5**	60	
	Rosera	152.8	207.4	392.2	154	2.2	**908.6**	58	
	Khagaria	119.2	218.5	252.1	108.9	1.8	**700.5**	53	
Bagmati	*Kathmandu*	256.4	400	265.2	283	9.6	**1214.2**	94	1125.6
	Nagarkot		53.4	57.2	71		**181.6**		1554.3
	Benibad	160.06	281	233.4	487.2	0	**1161.66**	51	
	Hayaghat	206.6	285.4	281	280.4	4.3	**1057.7**	58	
	Kamtaul	43.9	387.3	207	489.4	0	**1127.6**	51	
	Sonbarsa	125.4	170	130.2	181.4	0	**607**	50	
Kamla	Jainagar	71.4	467.3	196	352	0	**1086.7**	40	
	Jhanjharpur	114.2	344	149.4	235	2.2	**844.8**	59	
Kosi	*Okhaldunga*	81.2	335.4	225.7	323.5	55.4	**1021.2**	71	1401.6
	Taplejang	124.4	275.3	275.9	223.2	2	**900.8**	84	1404.6
	Dhankutta	159.5	149.7	159.8	56.1	0	**525.1**	52	722.5
	Biratnagar	174.3	243.3	274.3	112.9	0	**804.8**	53	1522.5
	Dharan	202.2	298.5	92.5	153.4	69	**815.6**	63	
	Basua	125.8	475.8	253.6	232.4	5.2	**1092.8**	70	
	Baltara	238.6	231.2	207.2	80.2	6	**763.2**	56	
	Kursela	313.8	198	253	262	5.2	**1032**	84	

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

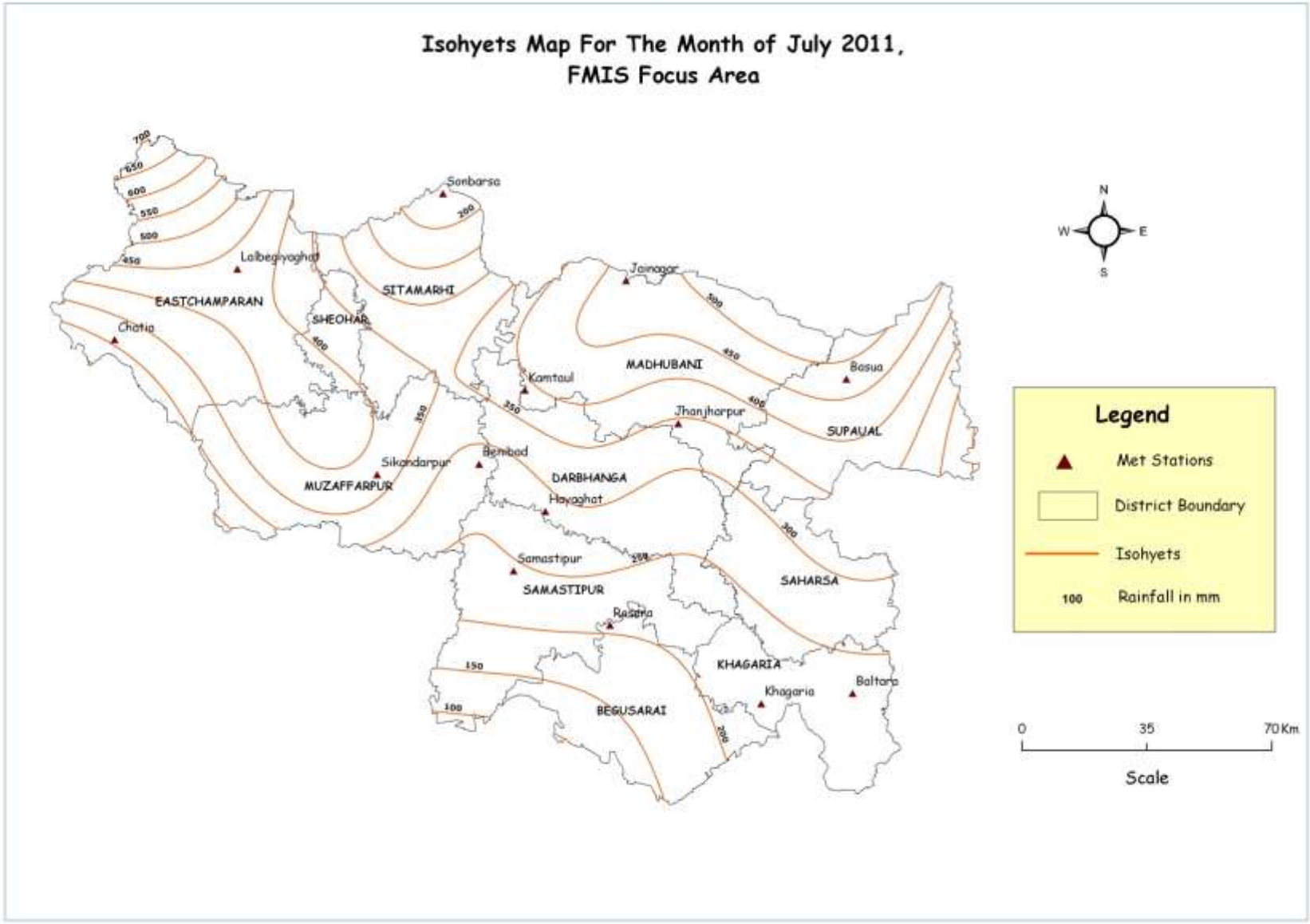
2. Monthly / monsoon rainfall have been calculated using daily rainfall obtained from CWC and Nepal web site www.mfd.gov.np.

3. Source of Normal Monsoon Rainfall for Nepal is the Nepal web site www.mfd.gov.np

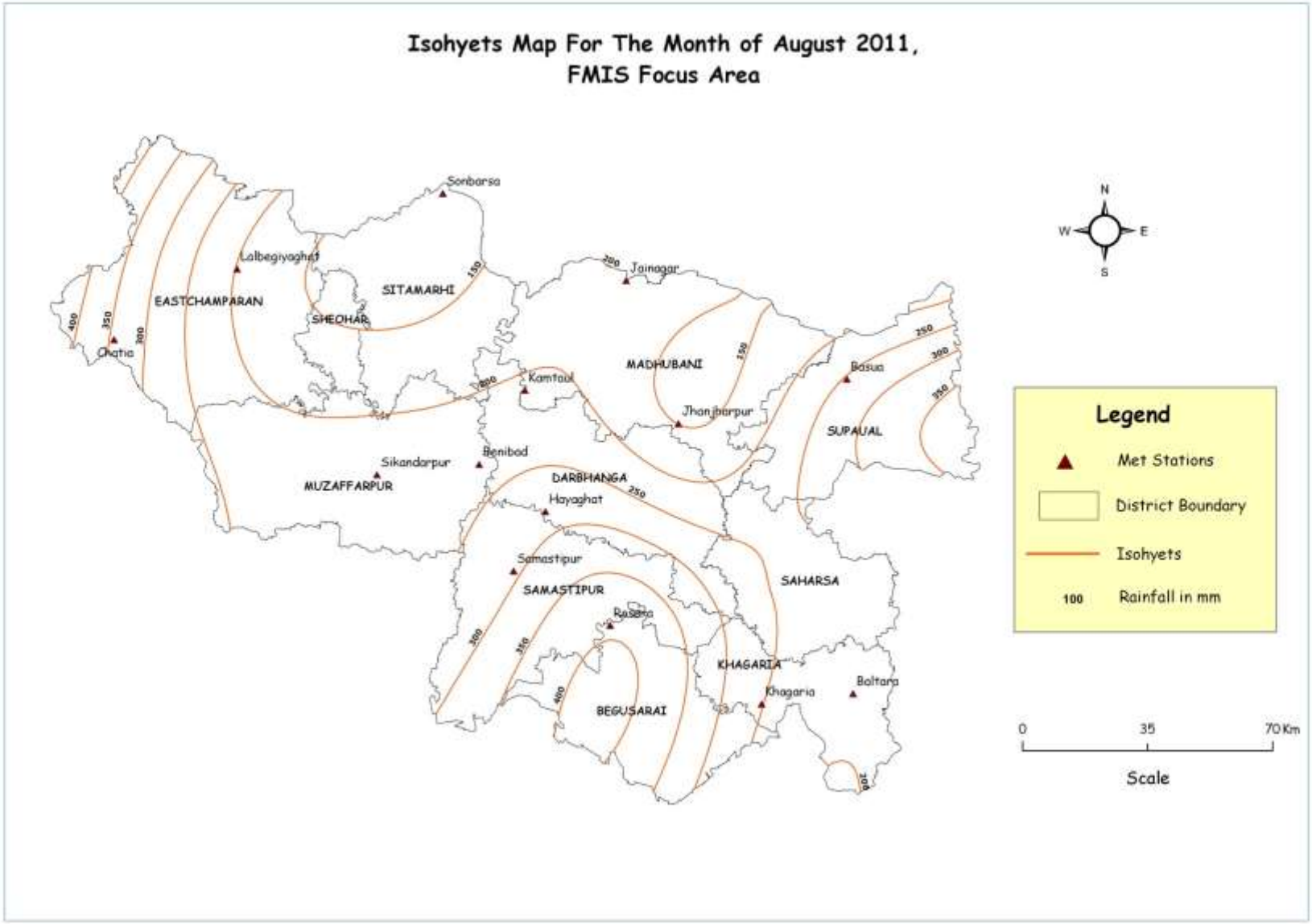
Map: 5.1.2


Isohyets Map For The Month of June 2011 (From 15th June),
FMIS Focus Area
Sonbarsa
Lalbegiyaghat
EASTCHAMPARAN
SHEOHAR
SITAMARHI
Jainagar
Chatia
Kamtaul
MADHUBANI
Basua
Thanjharpur
SUPAUAL
Benibad
Sikandarpur
MUZAFFARPUR
DARBHANGA
Hayaghat
Samastipur
SAMASTIPUR
SAHARSA
Rosera
KHAGARIA
Khagaria
Baltara
BEGUSARAI
N
W
E
S
Legend
Met Stations
District Boundary
Isohyets
100
Rainfall in mm
0
35
70 Km
Scale

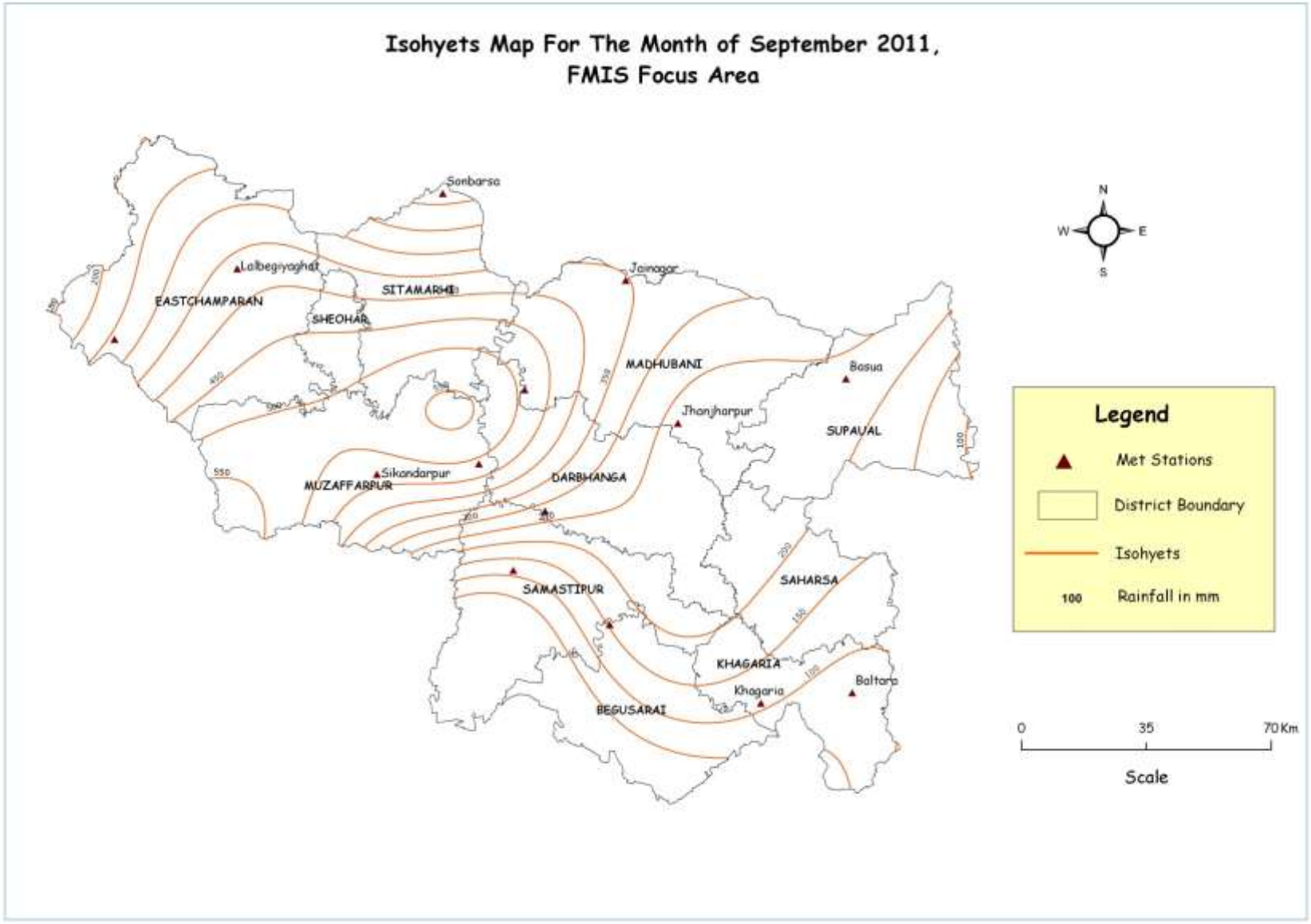
Map: 5.1.3


Isohyets Map For The Month of July 2011,
FMIS Focus Area
Sonbarsa
Lalbegiyaghat
EASTCHAMPARAN
SITAMARHI
SHEOHAR
Chatia
Jainagar
MADHUBANI
Basua
Kamtaul
Jhanjharpur
SUPAUAL
Benibad
Sikandarpur
MUZAFFARPUR
DARBHANGA
Hayaghat
Samastipur
SAMASTIPUR
SAHARSA
Rasera
KHAGARIA
Khagaria
Baltara
BEGUSARAI
N
W
E
S
Legend
Met Stations
District Boundary
Isohyets
100
Rainfall in mm
0
35
70 Km
Scale

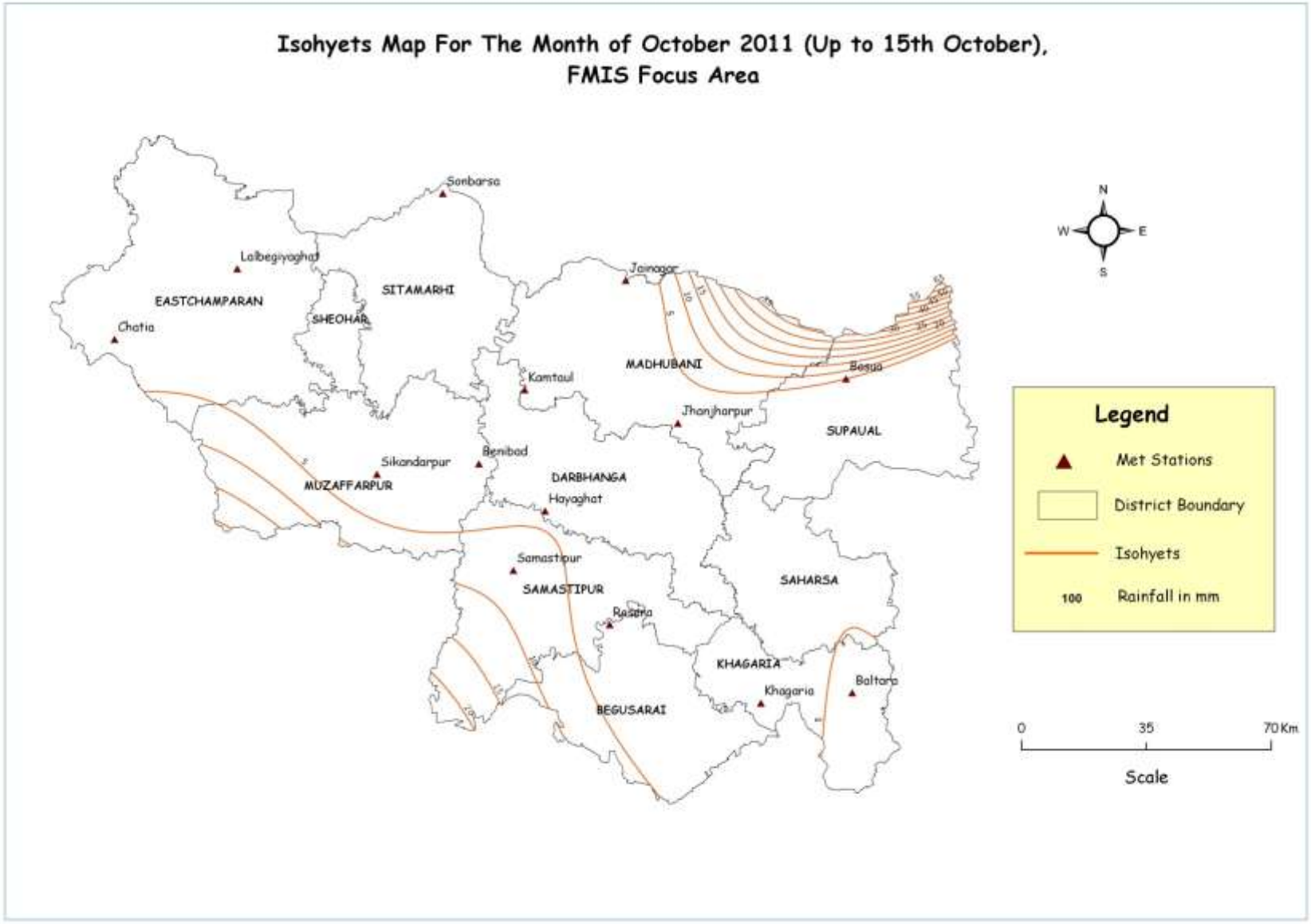
Map: 5.1.4


Isohyets Map For The Month of August 2011,
FMIS Focus Area
Sonbarsa
Lalbegiyaghat
EASTCHAMPARAN
SITAMARHI
SHEOHAR
Chatia
Jainagar
MADHUBANI
Kamtaul
Basua
Jhanjharpur
SUPAUAL
Benibad
Sikandarpur
MUZAFFARPUR
DARBHANGA
Hayaghat
Samastipur
SAMASTIPUR
SAHARSA
Rosera
KHAGARIA
Khagaria
Baltara
BEGUSARAI
N
W
E
S
Legend
Met Stations
District Boundary
Isohyets
100
Rainfall in mm
0
35
70 Km
Scale

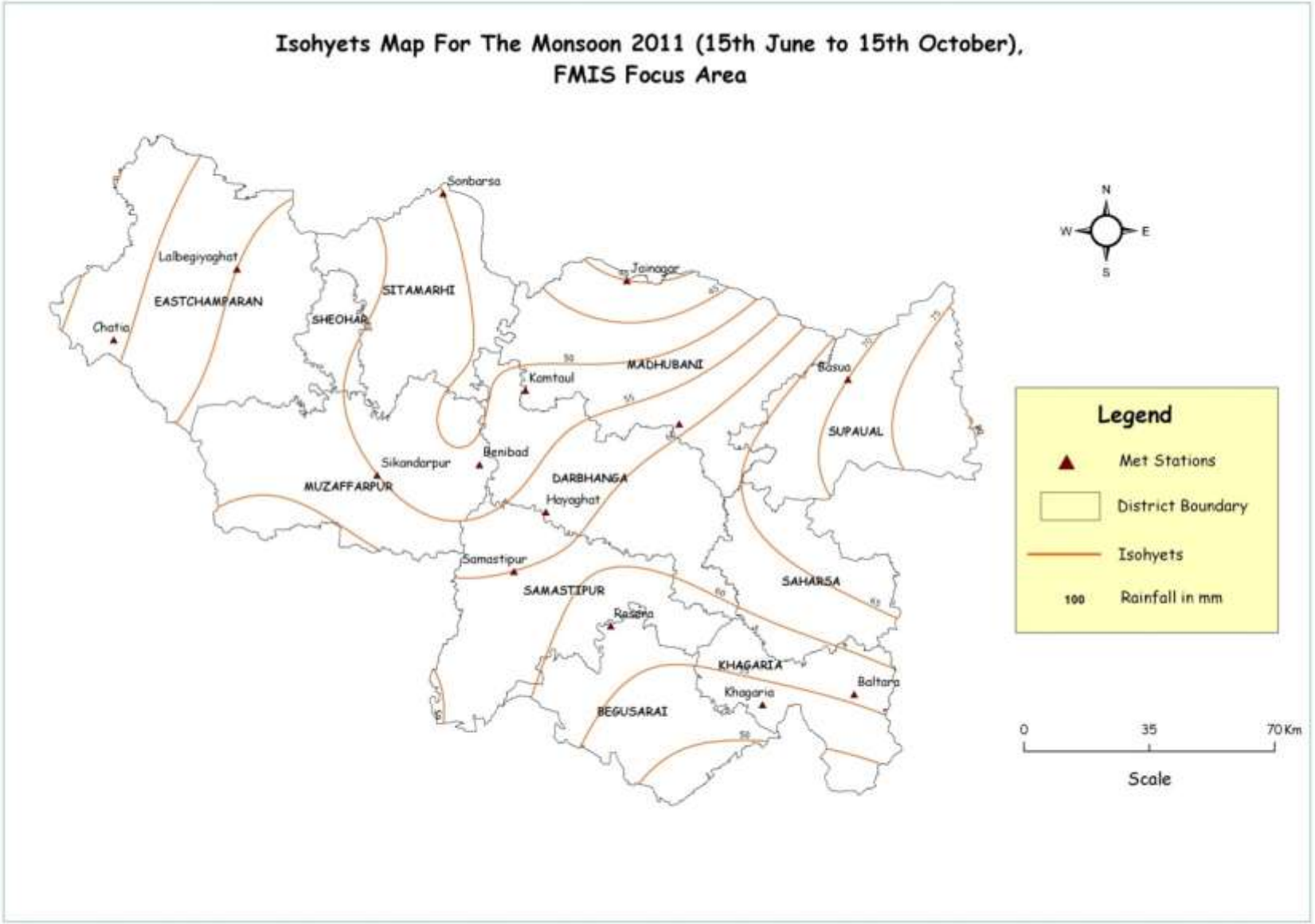
Map: 5.1.5


Isohyets Map For The Month of September 2011,
FMIS Focus Area
Sonbarsa
Lalbegiyaghat
EASTCHAMPARAN
SITAMARHI
SHEOHAR
Jainagar
MADHUBANI
Basua
Jhanjharpur
SUPAUAL
Sikandarpur
MUZAFFARPUR
DARBHANGA
SAMASTIPUR
SAHARSA
KHAGARIA
Khagaria
Baltara
BEGUSARAI
N
W
E
S
Legend
Met Stations
District Boundary
Isohyets
100
Rainfall in mm
0
35
70 Km
Scale

Map: 5.1.6


Isohyets Map For The Month of October 2011 (Up to 15th October),
FMIS Focus Area
Sonbarsa
Lalbegiyaghat
EASTCHAMPARAN
SITAMARHI
SHEOHAR
Chatia
Jainagar
MADHUBANI
Kamtaul
Benipatti
Jhanjharpur
SUPAUAL
Sikandarpur
MUZAFFARPUR
DARBHANGA
Hayaghat
Samastipur
SAMASTIPUR
SAHARSA
Rosera
KHAGARIA
Khagaria
Baltara
BEGUSARAI
N
W
E
S
Legend
Met Stations
District Boundary
Isohyets
100
Rainfall in mm
0
35
70 Km
Scale

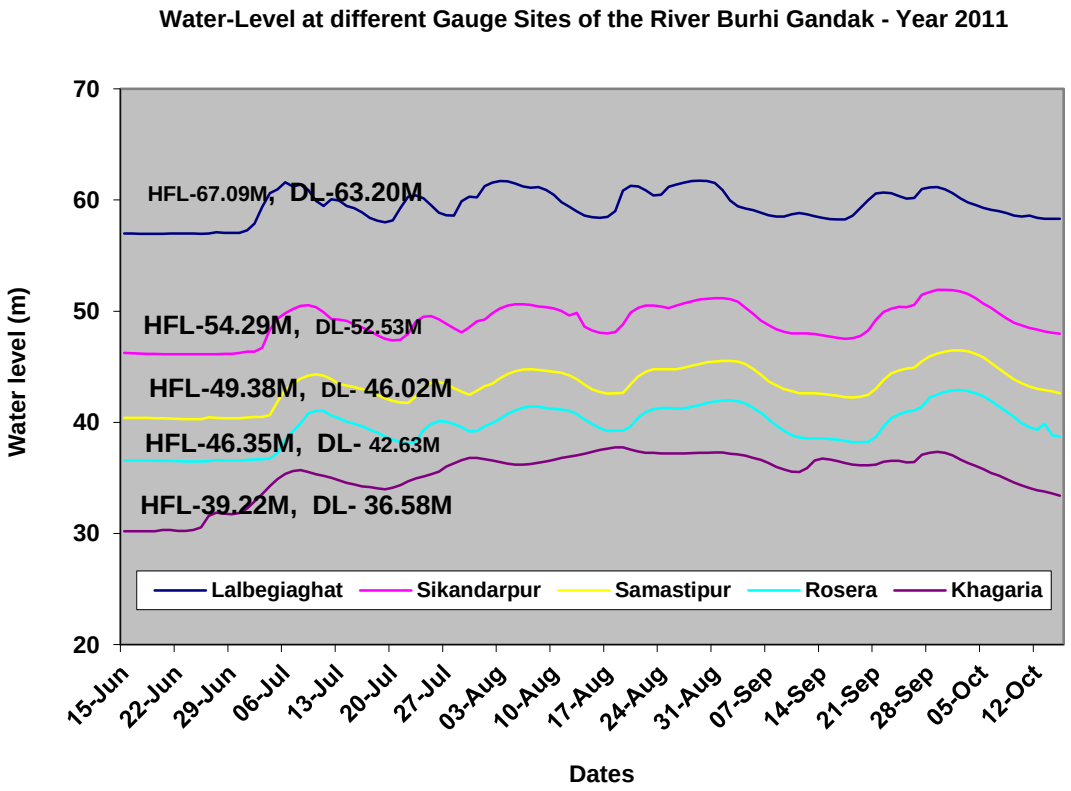
Map: 5.1.7


Isohyets Map For The Monsoon 2011 (15th June to 15th October),
FMIS Focus Area
Sonbarsa
Lalbegiyaghat
EASTCHAMPARAN
SITAMARHI
SHEOHAR
Chatia
Jainagar
MADHUBANI
Kamtaul
Basua
SUPAUAL
Sikandarpur
Benibad
MUZAFFARPUR
DARBHANGA
Hayaghat
Samastipur
SAMASTIPUR
SAHARSA
Rasera
KHAGARIA
Khagaria
Baltara
BEGUSARAI
N
W
E
S
Legend
Met Stations
District Boundary
Isohyets
100
Rainfall in mm
0
35
70 Km
Scale

5.2 River Stages during 2011 floods

Daily water-levels measured (at 6:00 AM) during 2011 floods at different gauge stations on four major rivers of the Area of Interest viz. Burhi Gandak, Bagmati, Kamla and Kosi have been chronologically plotted and discussed below.

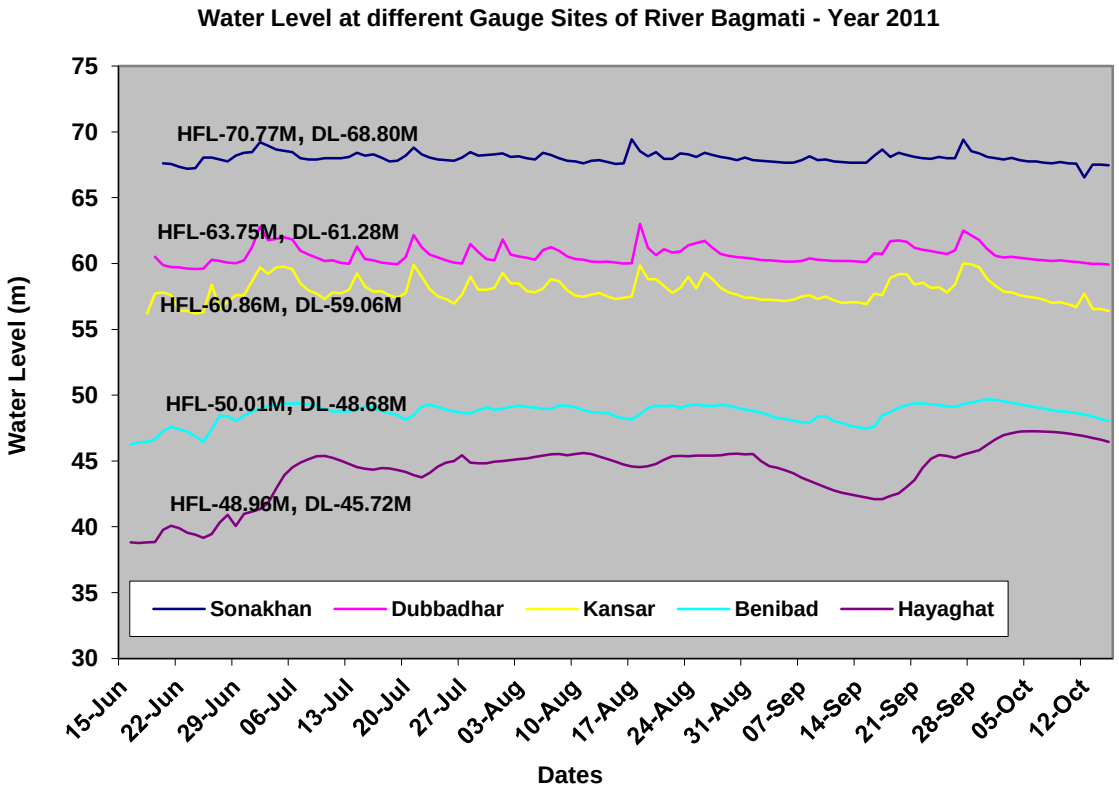
5.2.1 Burhi Gandak



Lalbegiaghat, Sikandarpur, Samastipur, Rosera and Khagaria are five gauge-stations located in sequence from up-stream to down-stream on the river Burhi Gandak. Water level remained almost constant in the month of June at Lalbegiaghat, Sikandarpur, Samastipur and Rosera and up to 24th June at Khagaria. Water level of all stations started rising from beginning of the month July except Khagaria where it rose from 25th June. The first peak came on 6th July at Lalbegiaghat, on 9th July at Sikandarpur, on 10th July at both Samastipur and Rosera and on 7th July at Khagaria, but all these peaks remained below the danger level at each stations. After then fall in water level continued till 23rd July. Second peak of low magnitude came between 24-26 July at all these stations. The water level started rising again in the beginning of the month August and attained a peak of 61.67 m and 50.5 m on 4th August at Lalbegiaghat and Sikandarpur respectively, 44.78m and 41.45m on 7th August at Samastipur & Rosera and 37.76m on 18th Aug. at Khagaria. Water level crossed the danger level on 10th August and remained above the Danger level up to 6th September at Khagaria station. During the month of August, the minimum water level reached on 18th August at all four up-stream stations, however on the same day the water level was maximum at Khagaria. After 18th August, Water level rose and continued rising till 31st August except Khagaria which had falling trend. till 18th September. Rising continuously thereafter, the river stage attained a peak on 29th September, 30th September, 1st October, 3rd October and 29th September

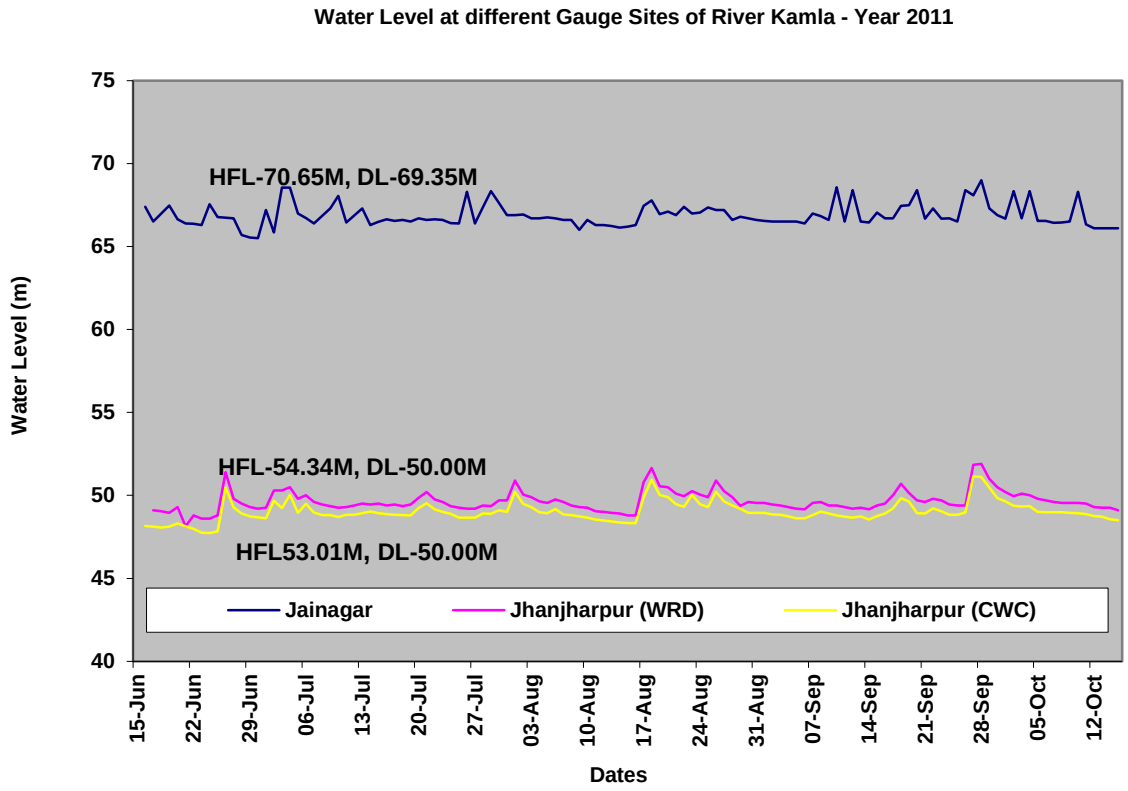
respectively at stations from up-stream to downstream. Then there was continuous fall in water level profile as monsoon was over.

5.2.2 Bagmati



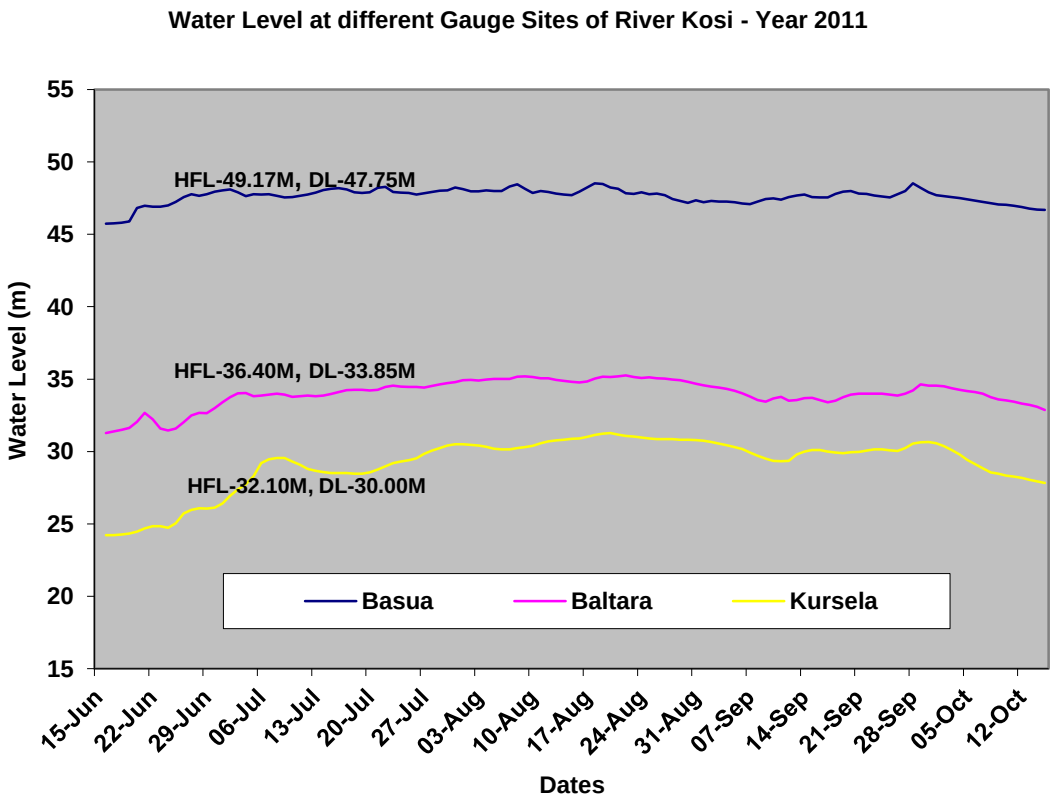
Sonakhan, Dubbadhar, Chandauli/Kansar, Benibad and Hayaghat are five gauge stations located in sequence from up-stream to down-stream on the river Bagmati. Chronological plot of water levels at the upper stations shows relatively low rise and fall at Sonakhan in comparison to that at Dubbadhar and Chandauli. Water levels at Dubbadhar and Kansar show the same trend of flow. Water level crossed the danger level of 68.8m on 2nd July, 17th Aug, and 27th Sept at Sonakhan station during this flood season. The water level crossed the danger level on 2nd July to 6th July, 21st July, 28th July, 1st Aug, 18th Aug, 19th Sept and 28th Sept at Dubbadhar and Kansar. Water levels at Dubbadhar and Kansar seem to have good correlation. Water levels crossed the danger level on 1st July at Benibad and remained above Danger level most of the period in this flood season. River stage graph shows flatter profile of water level at Benibad. Water level at Hayaghat continuously rose up to 9th July having a peak of 45.35m and remained steady up to 31st August. After this, there was continuous recession till 17th Sept followed by rising trend till 3rd October. It crossed the Danger level on 29th September and remained above danger level till last of the flood season. The correlation between Benibad and Hayaghat water level does not appear to be good.

5.2.3 Kamla



Jainagar (weir site), Jhanjharpur rail bridge (maintained by WRD) and Jhanjharpur (d/s of rail bridge maintained by CWC) are three gauge stations located in sequence from upstream to downstream on the river Kamla. The maximum stage level of this river in the month of June, July, August, September and October were 67.55m (24th June), 68.55 m (3rd July), 67.78 m (18th Aug), 69.00m (28th Sept) and 68.35m (4th October) respectively at Jainagar. Water level remained below the danger level (69.35m) throughout this season at Jainagar. However water level crossed the danger level seven times (on 26th June, 4th July, 1st Aug, 18th Aug, 23rd Aug, 26th Aug and 27-29th Sept) at Jhanjharpur this season. The highest peak in this year was 51.90 m on 28th September at Jhanjharpur and this time water level remained above the danger level from 27th September to 1st October. Water level pattern at U/S and D/S of Jhanjharpur rail bridge is quite parallel. The water level profile at Jainagar and Jhanjharpur is not matching. The correlation coefficient between Jainagar and Jhanjharpur (WRD) is 0.40 and between U/S and D/S of Jhanjharpur rail bridge is 0.97.

5.2.4 Kosi



Basua, Baltara and Kursela are three gauge stations located in sequence from up- stream to down-stream on the river Kosi. The correlation coefficient between water level of Basua and Baltara is 0.70 and between Baltara and Kursela is 0.90. Water level at Basua crossed the danger level (47.75m) on 27th June and attained a peak of 48.04 m on 1st July, 48.15 m on 15th July, 48.22 m on 21st July, 48.29 m on 7th Aug, 48.53m on 18th August, and 48.52 m on 28th September. Water level at Baltara first crossed the danger level of 33.85 m on 3rd July and remained above danger level upto 6th September having a peak of 35.26 m on 22nd August. The water level at Kursela started rising from beginning of the flood season and attained a peak of 29.56 m on 8th July. The water level exceeded the danger level on 31st July and remained above danger level (30m) up to 3rd October.

5.3 Effect of rainfall in the Nepal region on the river-stages in Bihar

River gauge stations in Area of Interest close to the Indo-Nepal border are Lalbegiaghat on Burhi Gandak, Sonakhan on Bagmati, Jainagar on Kamla and Basua on Kosi. Daily river water levels measured at these stations vis-a-vis daily average rainfall of the respective basin above these locations have been plotted on the same charts. Rain-gauge stations considered for averaging are as follows:

Name of basin	Part under consideration	Rain-gauge stations considered for averaging
1	2	3
Burhi Gandak	Up to Lalbegiaghat	Simara, Lalbegiaghat
Bagmati	Up to Sonakhan	Simara, Kathmandu, Nagarkot, Garuda
Kamla	Up to Jainagar	Janakpur*, Sindhuli, Okhaldunga
Kosi	Up to Basua	Okhaldunga, Taplejang, Dhankutta, Biratnagar, Dharan, Basua

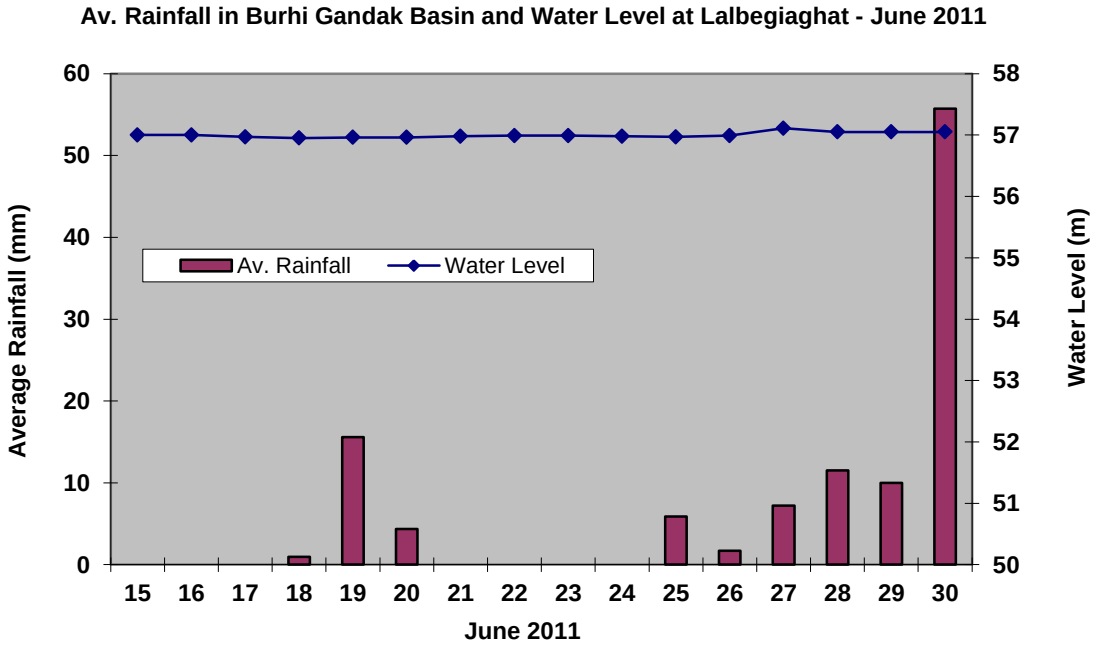
*This year rainfall data for Janakpur in Kamla basin could not be available either from CWC or Nepal website. Hence, the average rainfall for Kamla basin has been taken as the rainfall at Sindhuli and Okhaldunga only.

Since the rainfall stations are less in number, the correlation between average rainfall and water level of different rivers may not be truly matching because of temporal and spatial variability.

Number of rain-gauge stations is too less to account for the aerial variability of rainfall. Therefore, instead of using rigorous methods, simple arithmetic mean has been used for averaging the rainfall. Basin wise rainfall pattern and corresponding water level are discussed in the following paragraphs.

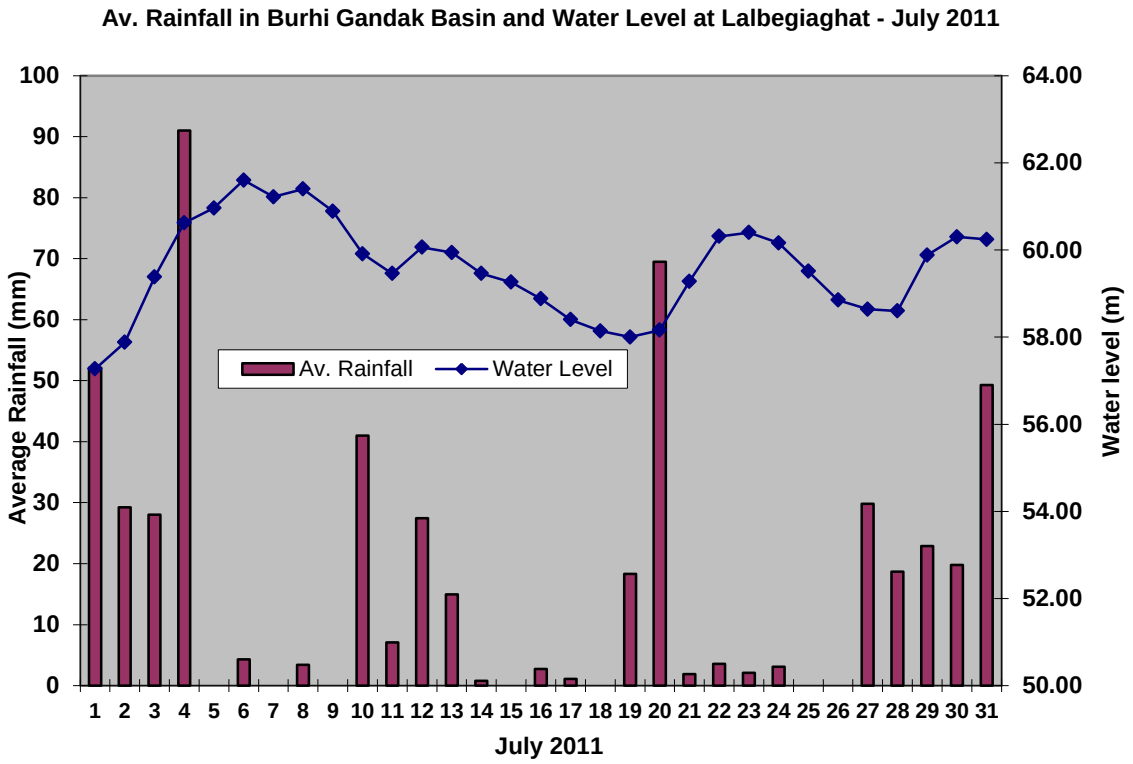
5.3.1 Burhi Gandak

a) During June - 2011



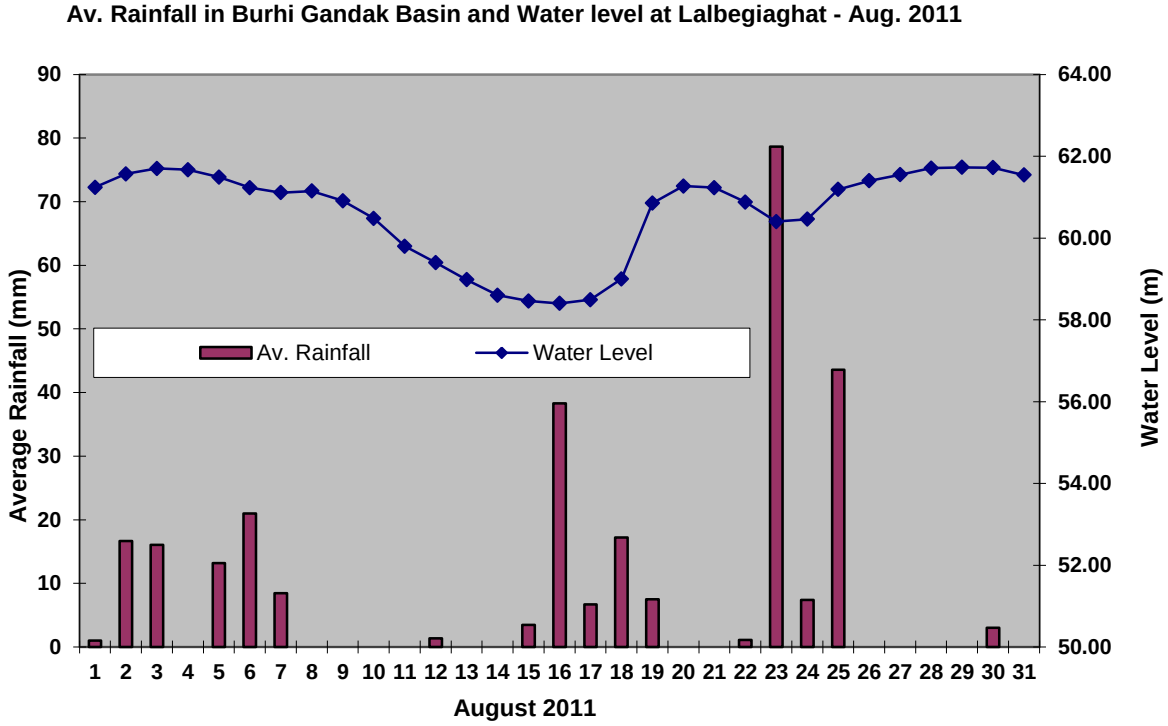
There was no significant rainfall between 15th-29th June over the catchment area of Lalbegiaghat. The plot of water level in the month of June shows no significant effect of rainfall. On 30th June average rainfall of 55.7mm occurred in the upper catchment.

b) During July - 2011



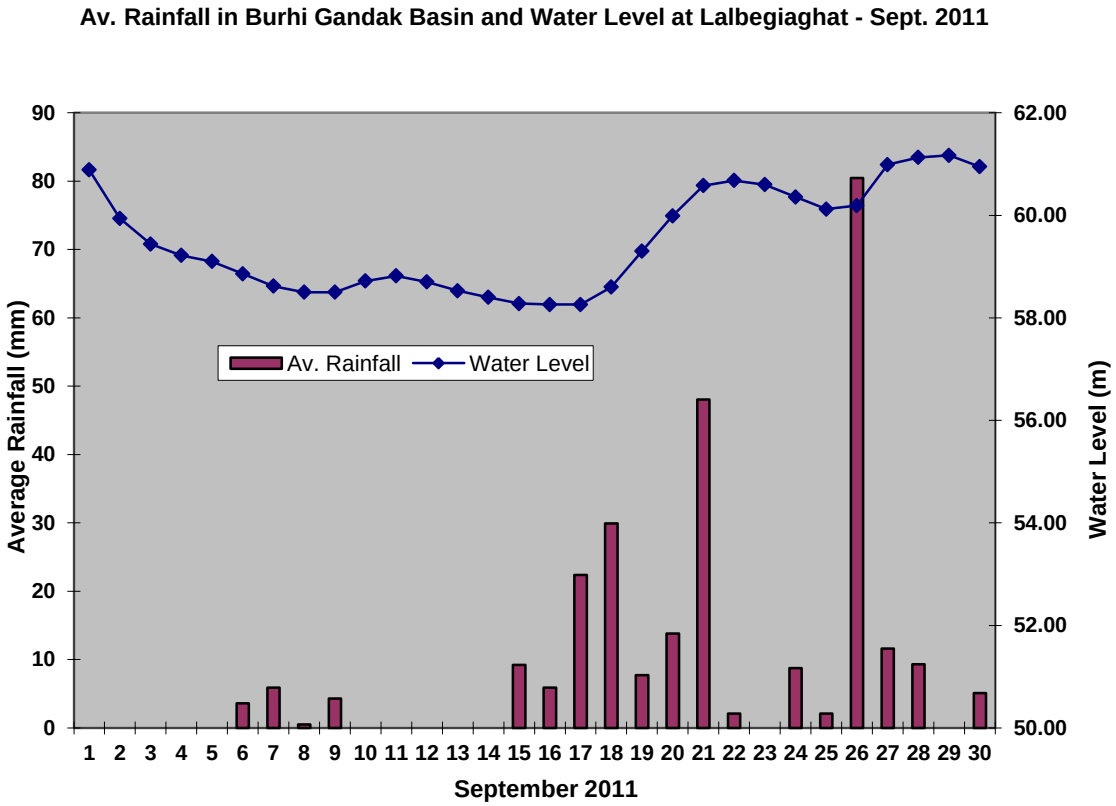
There was continuous rainfall from 30th June to 4th July resulting in continuous rise in water level at Lalbegiaghat, which reached a peak of 61.60m on 6th July. Thereafter, the effective rainfall occurred on 10th, 20th and 27th-31st July which resulted in peaks of water level on succeeding dates.

c) During August - 2011



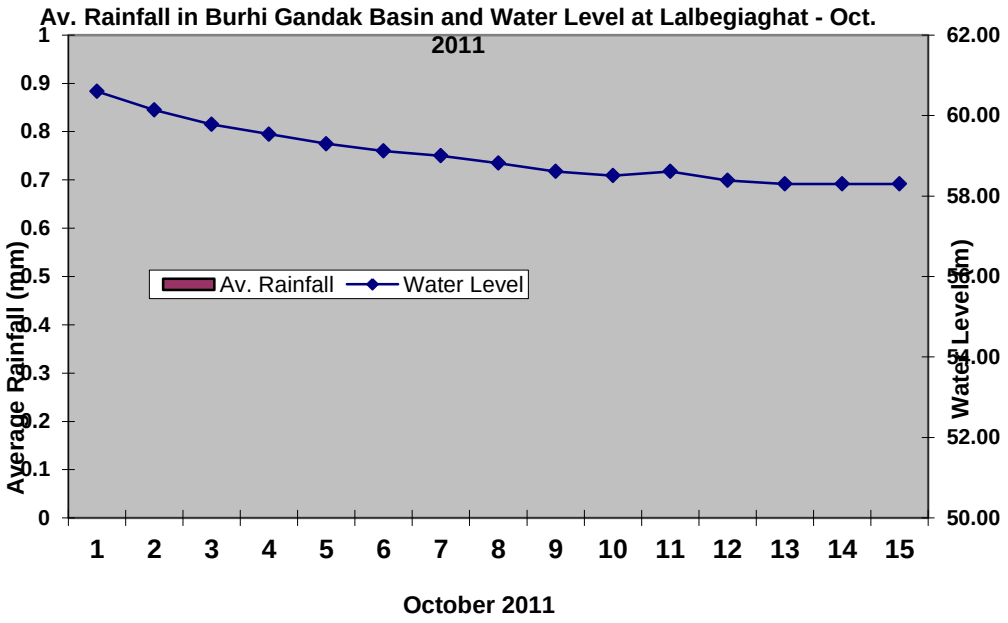
The August stage rainfall graph indicates no effective rainfall till 16th August. Another storm of rainfall occurred between 15th to 19th August which resulted in water level rising to 61.27m on 20th August. The average rainfall of 78.65mm and 43.6mm occurred on 23rd and 25th July respectively. Due to this rainfall, the water level continuously increased till 30th August.

d) During September - 2011



Thereafter water level continuously decreased till 17th September due to ineffective rainfall in upper catchment. A storm of rainfall came between 15th-21st September, resulting in a peak of 60.68m on 22nd September. Again an average rainfall of 80.45mm occurred on 26th September, which was maximum during this month producing the highest stage level of 61.17m on 29th September.

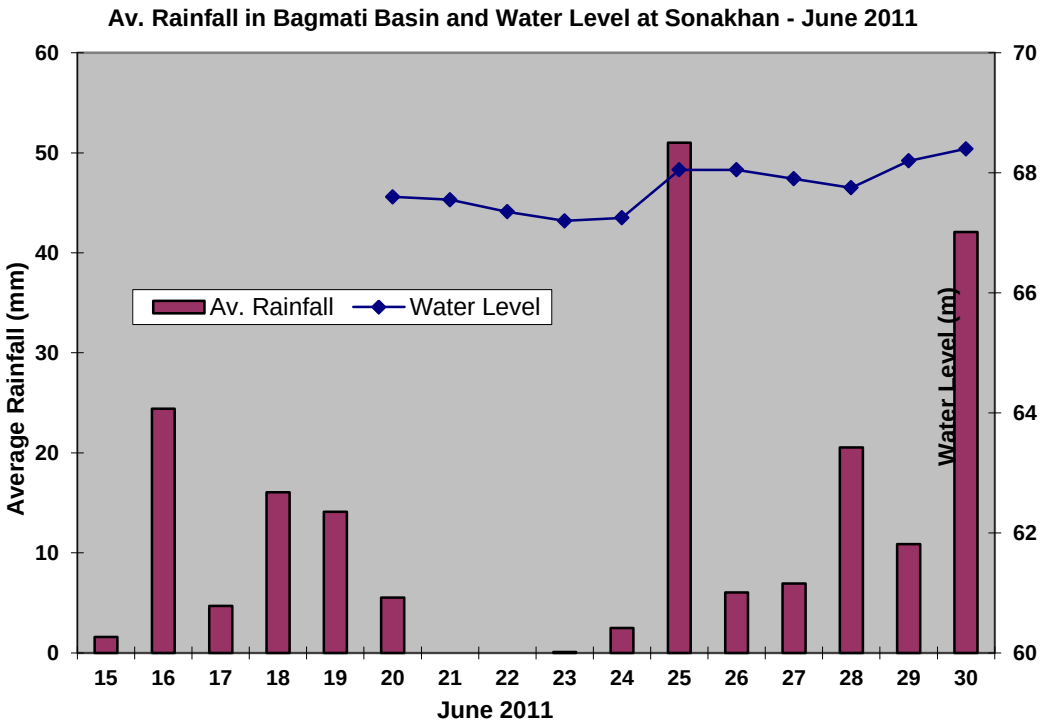
e) During October - 2011



Water level slowly receded by 15th October i.e, the end of the season. There was no rainfall in October.

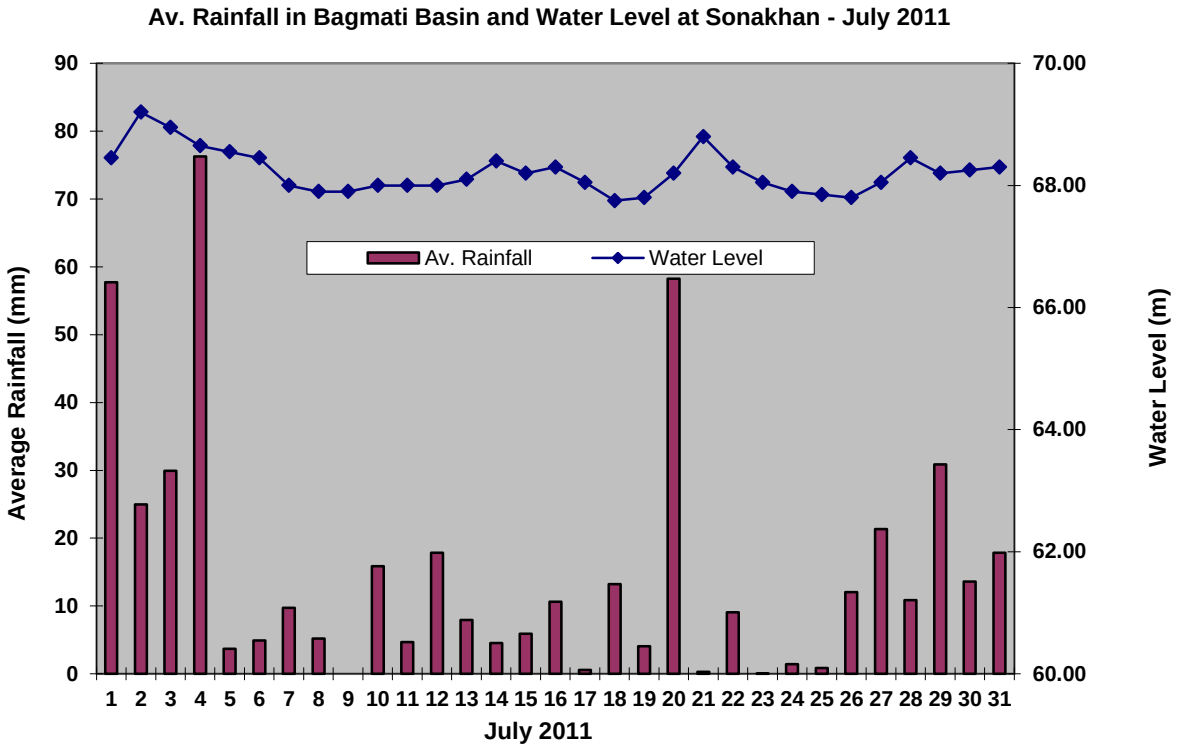
5.3.2 Bagmati

a) During June - 2011



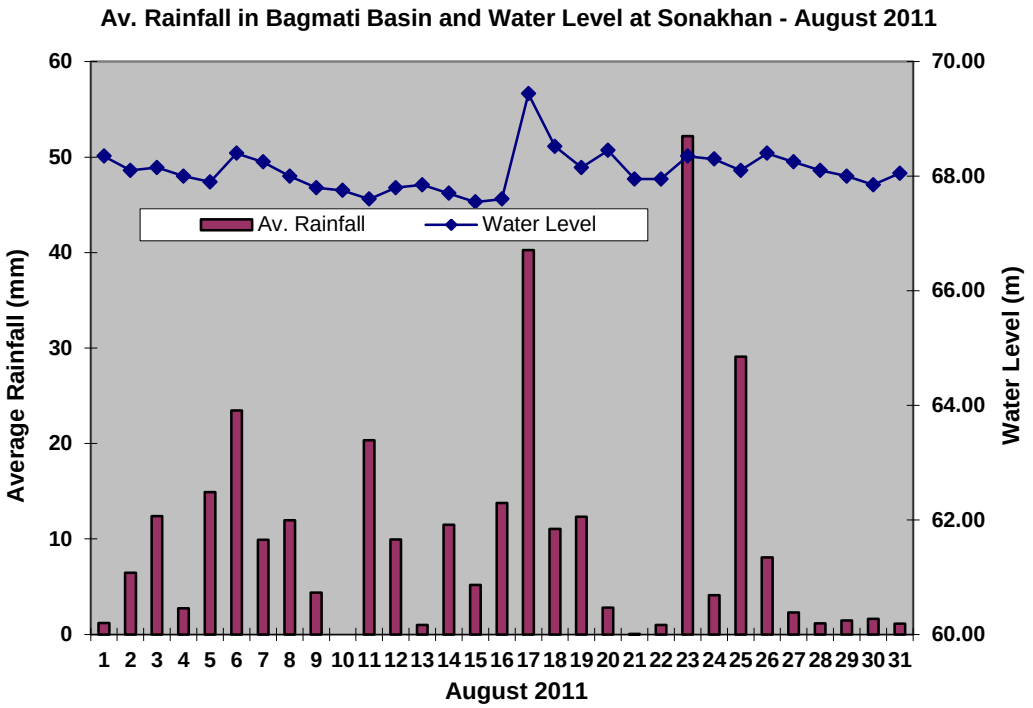
Water level data from 15th June to 19th June at Sonakhan was not available. However there was some rainfall during this period. Water level has continuously fallen till 24th June. An average rainfall of 51 mm over the upper catchment of Sonakhan occurred on 25th June which resulted in increase of water level of 0.80m on 25th June. After this, an effective rainfall occurred during 28-30th June and water level started rising up to 30th June.

b) During July - 2011



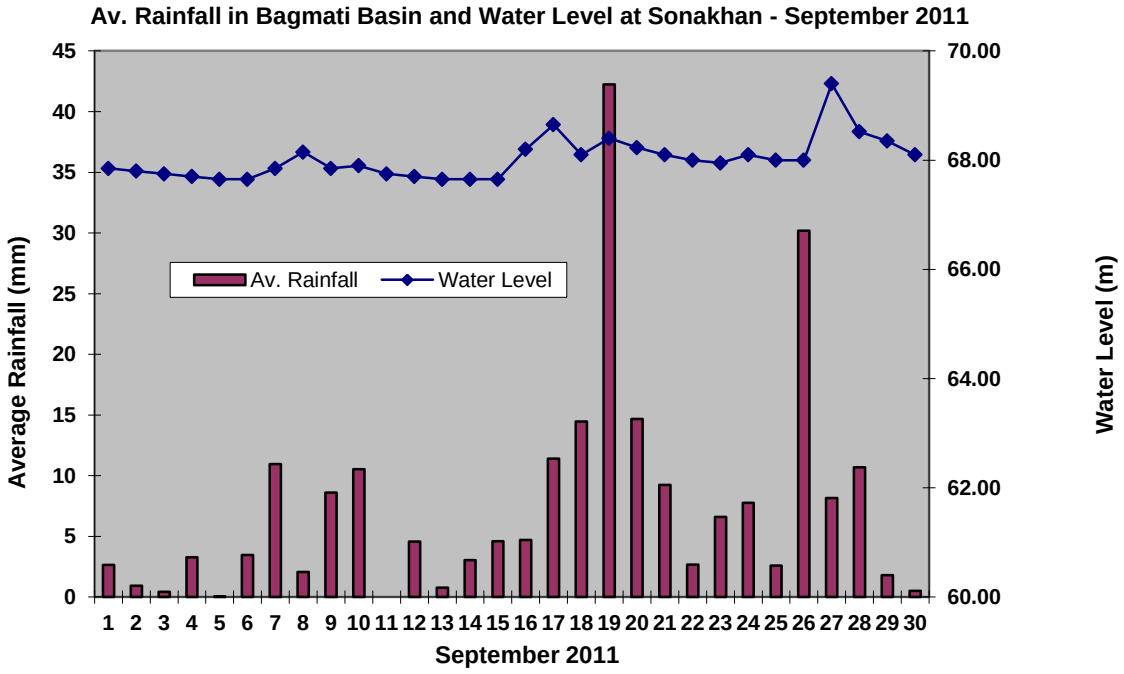
In the beginning of July, effective rainfall occurred up to 4th July. There was a rainfall of 76.285 mm on 4th July, but it had not much impact on water level. Then due to scanty rainfall upto 19th July water level receded or remained constant. Again average rainfall of 28.25 mm occurred on 20th July, due to which water level rose up to 68.80 m on 21st July. Then water level receded up to 26th July. During 26-31st July, rainfall of small magnitude occurred which resulted in rising profile of water level.

c) During August - 2011



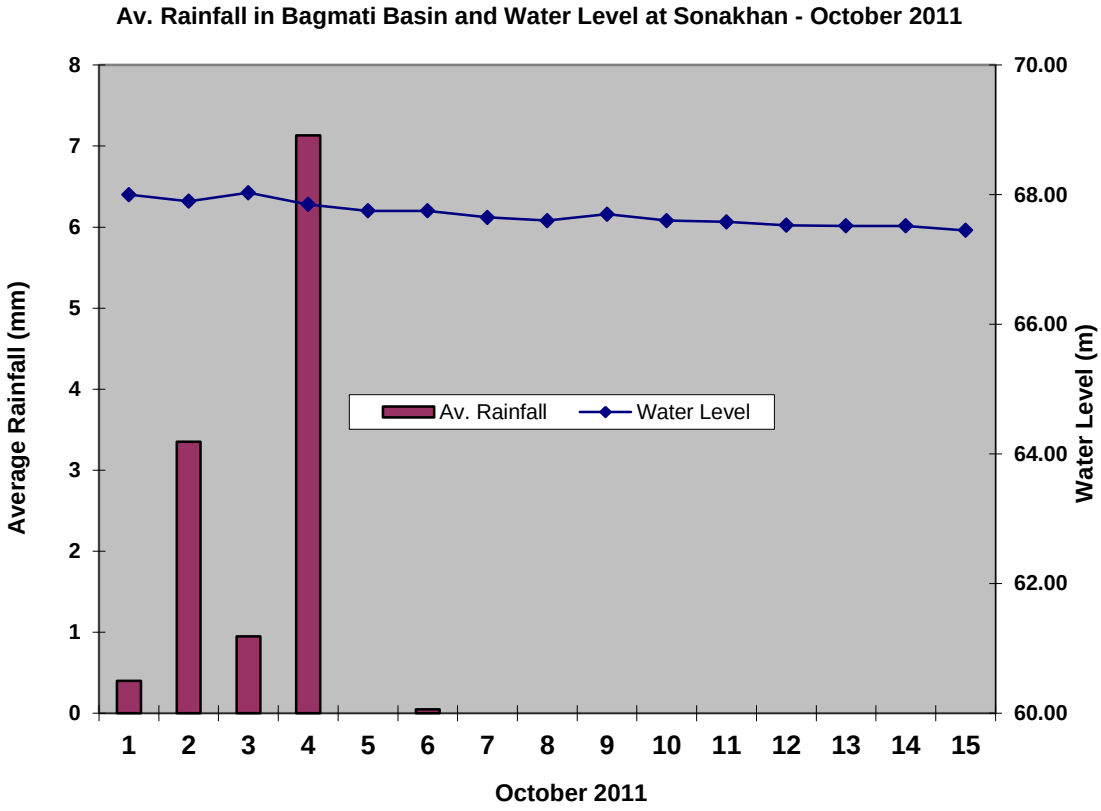
In the month of August the appreciable rainfall occurred on 6th , 11th, 17th ,23rd and 25th August. These rainfall raised the water level at Sonakhan on succeeding days. The maximum stage level was 69.44 m on 17th August.

d) During September - 2011



Water level remained almost constant during 1-15th September. Due to rainfall storm during 17-21st September, water level rose up to 68.65 m on 17th September. The maximum average rainfall in the catchment during September month was 42.25 mm on 19thSeptember. Again water level rose by 1.4 m on 27th September due to an average rainfall of 30.175 mm on 26th September.

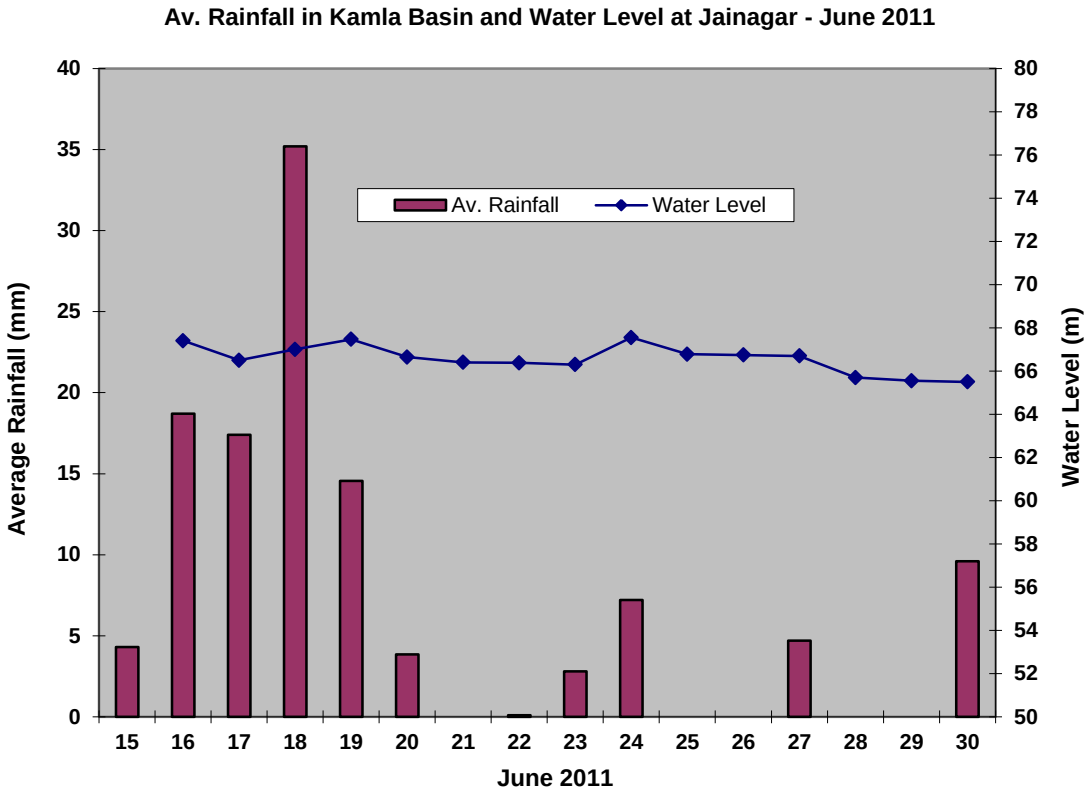
e) During October - 2011



The water level graph of October shows that there was continuous recession in water level up to 15th October. There was no significant rainfall in this month.

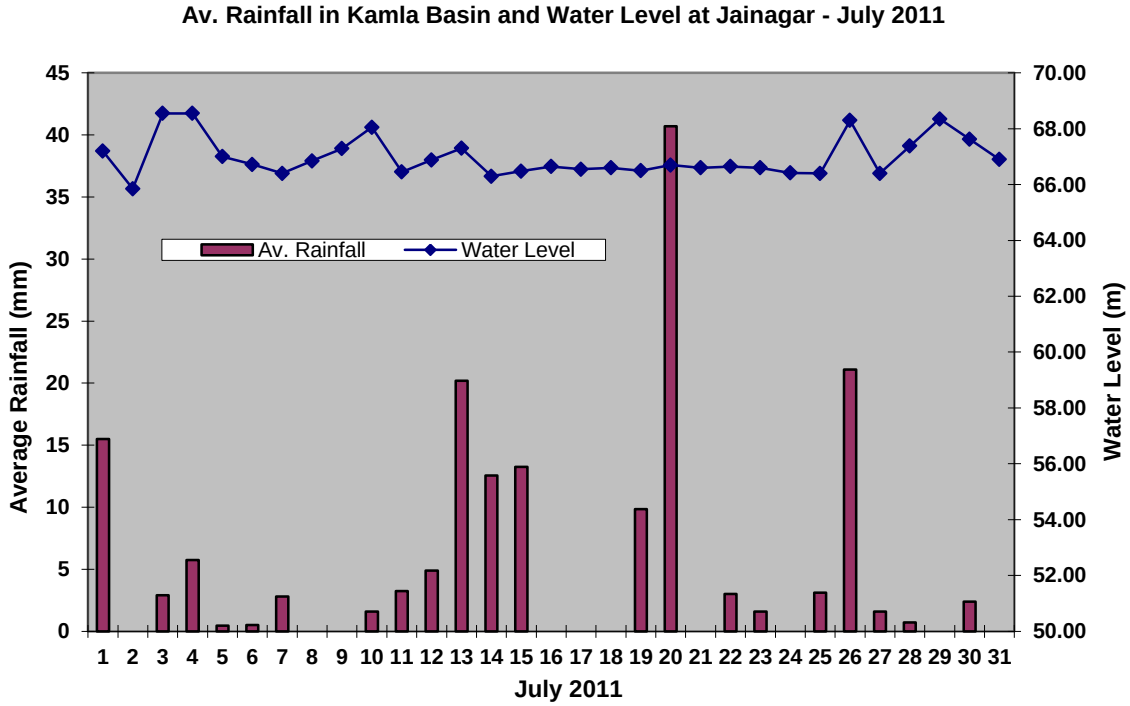
5.3.3 Kamla

a) During June - 2011



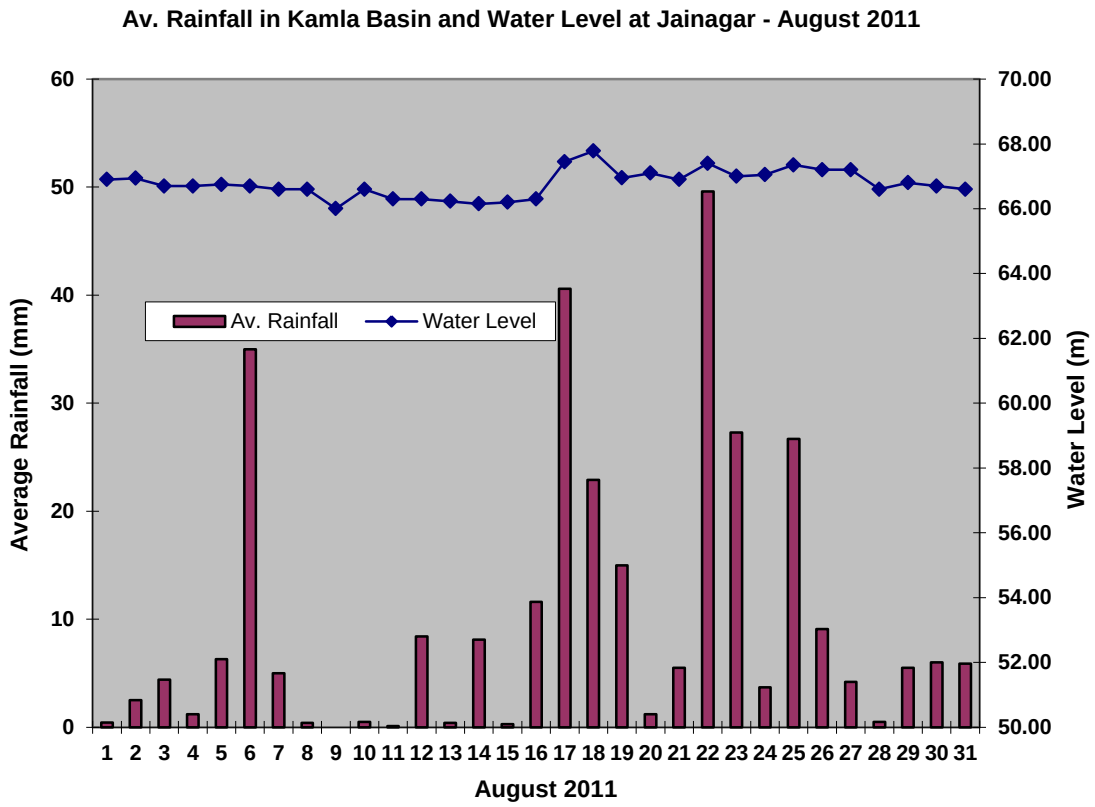
In the beginning of flood season, there was some rainfall in the upper catchment of Jainagar site. This resulted in a peak of 67.47m on 19th June. Afterward there was falling trend till end of this month.

b) During July - 2011



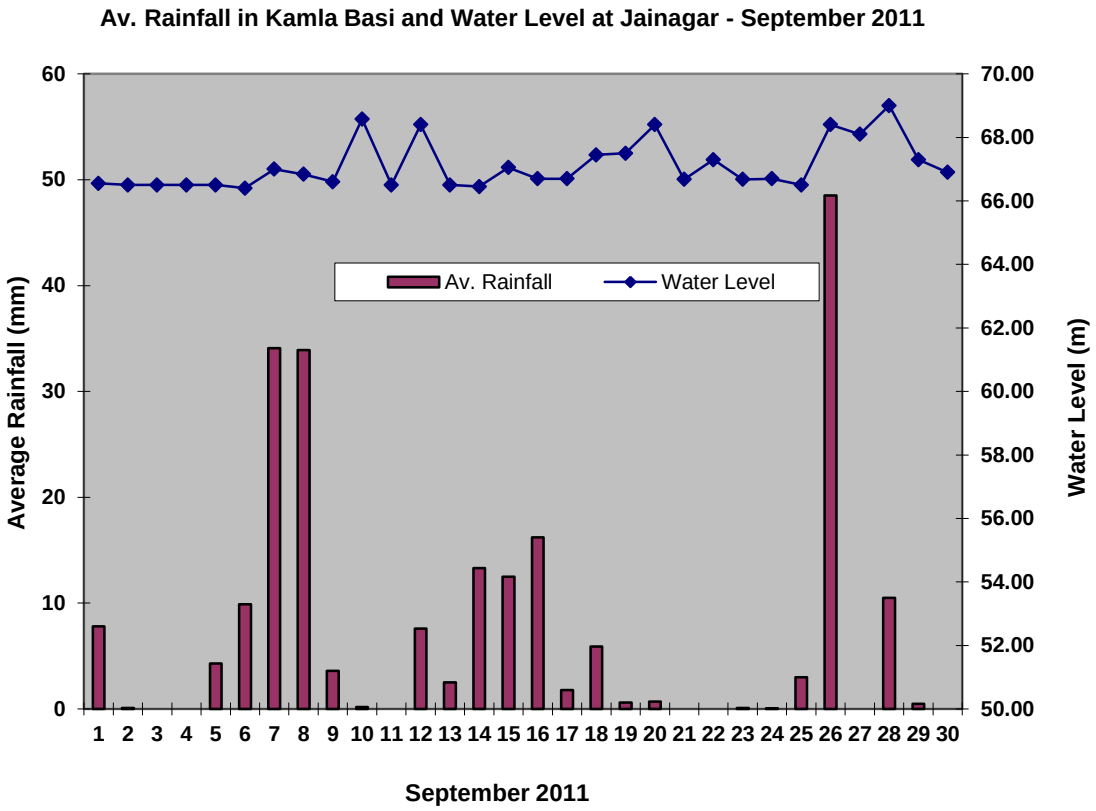
Average Rainfall and water level graph at Jainagar for the month of July were not matching. The plot showed sudden rise and fall at several points, which was not correlating with actual rainfall. The maximum average rainfall of 40.7mm occurred on 20th July, but it had no impact on water level at Jainagar. This may also reflect that rainfall was not the only factor influencing the water level. This might be due to gate operation of Kamla weir at Jainagar.

c) During August - 2011



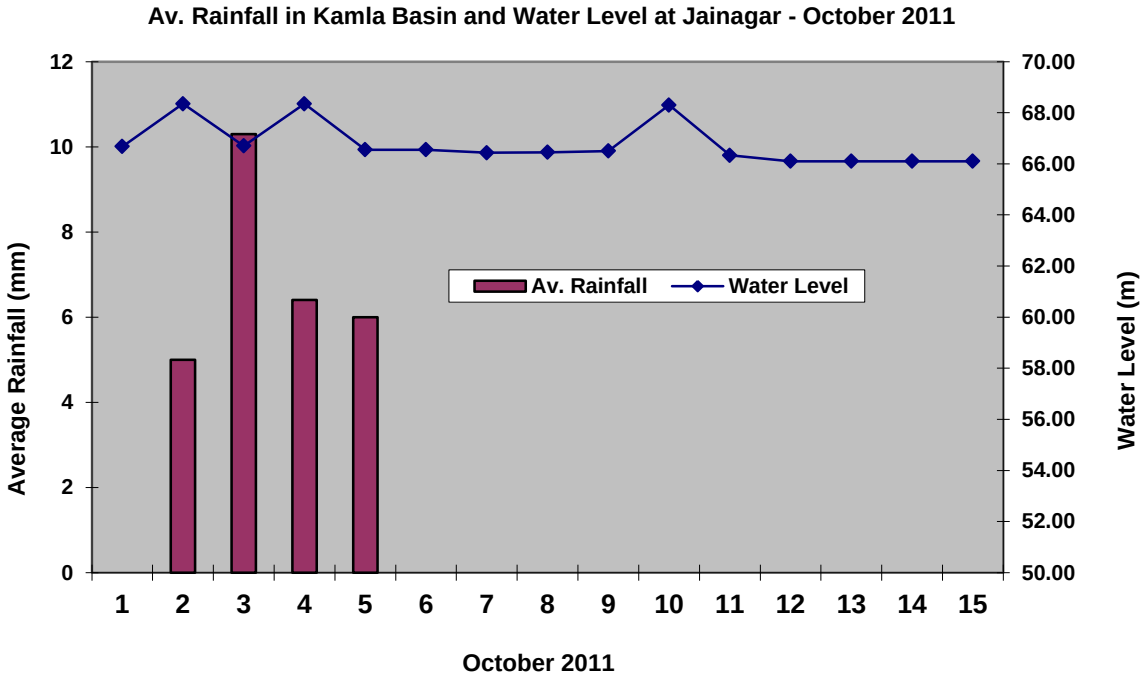
Due to insignificant rainfall from 1st August to 16th August the water level remained almost constant. However, later there was significant rainfall varying from 22.9mm to 49.6mm in the catchment which raised the water level at the site. The maximum water level was 67.78m on 18th August and then receded up to 66.60m on 31st August.

d) During September - 2011



Water level remained constant from 1st September to 6th September. There was average rainfall of 34.1mm & 33.9mm on 7th and 8th September respectively. This resulted in peaks of 68.58m and 68.40m on 10th and 12th September respectively. But the water level on 11th September was 66.50m, which seems erroneous or it may be due to some other reasons. Afterward, there was no significant rainfall till 25th September, but there was some fluctuations in water level. Again on 26th September, there was rainfall of 48.5mm which raised the water level up to 69.00m on 28th September.

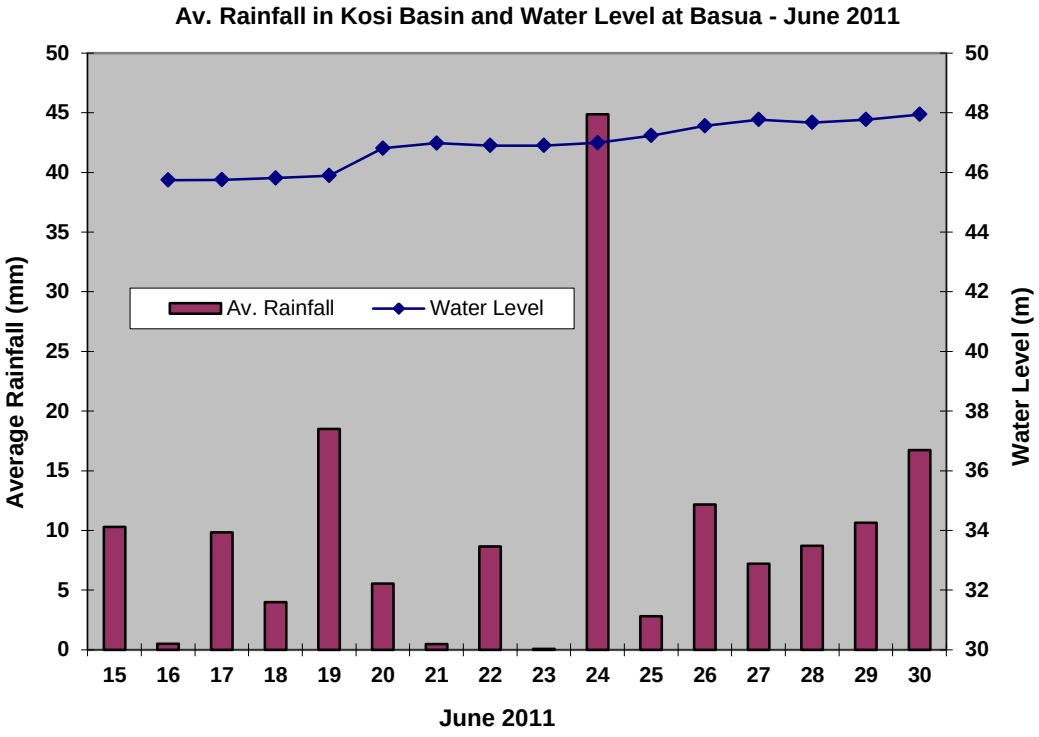
d) During October - 2011



There were three peaks of 68.35m, 68.35m and 68.30 m on 2nd October, 4th October and 10th October respectively and for other days the water level remained almost constant. There was no effective rainfall in the month of October.

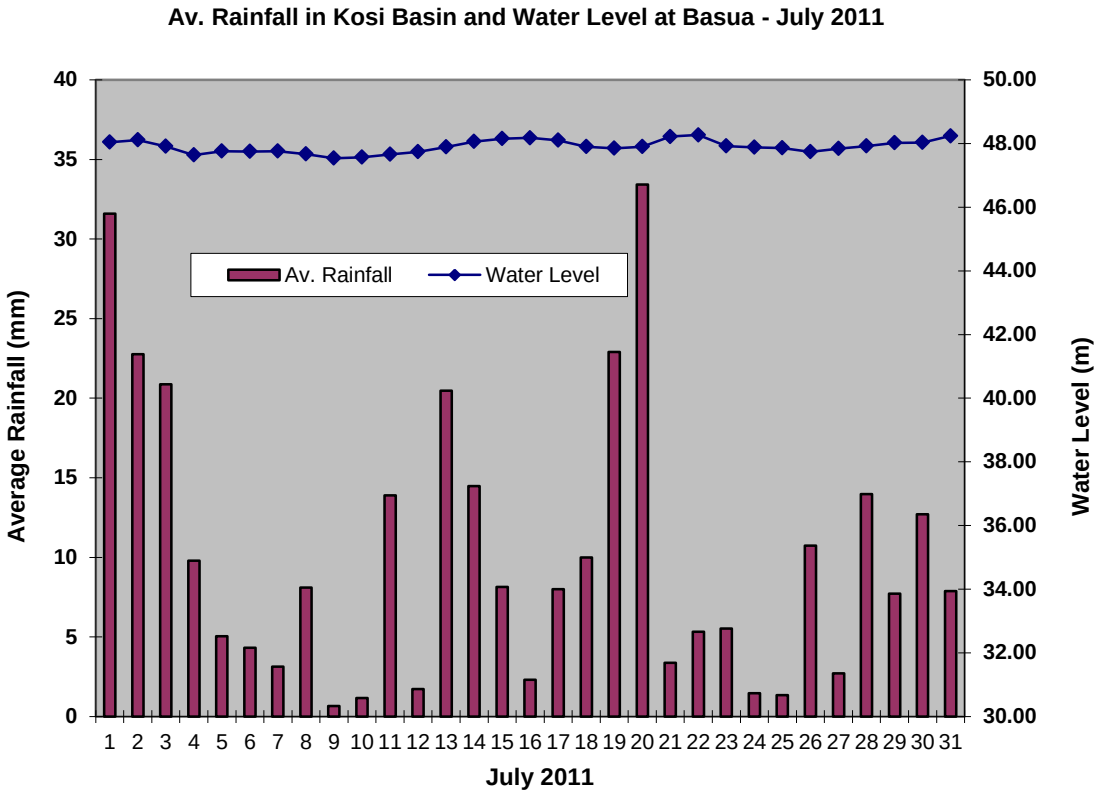
5.3.4 Kosi

a) During June - 2011



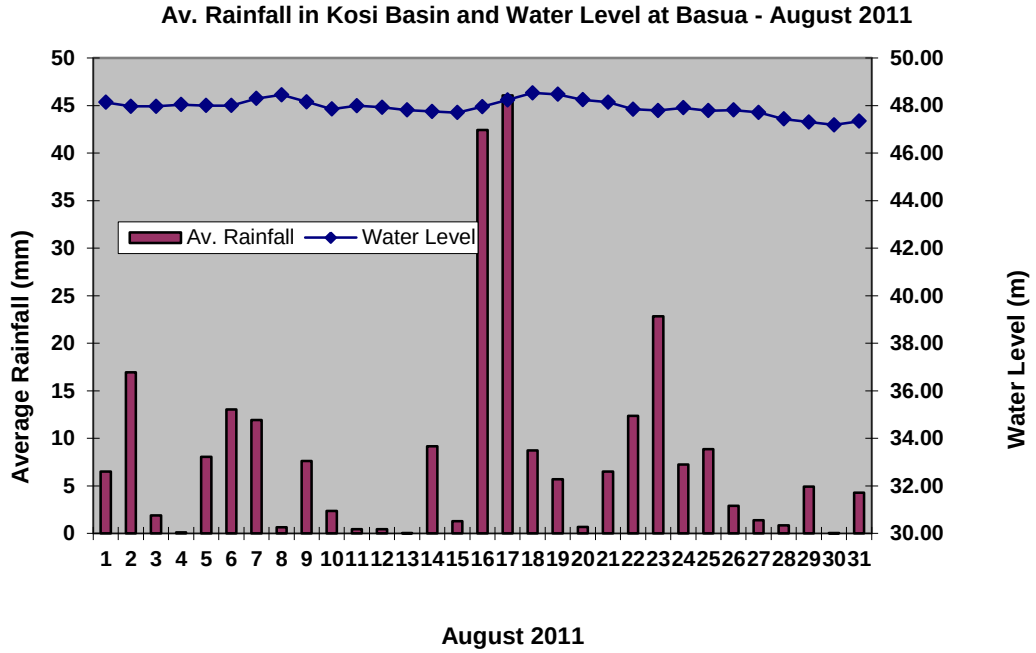
Water level was constant up to 19th June. The average rainfall on 19th June was 18.5 mm, which increased the water level by 0.90m on 20th June. Again there was an average rainfall of 44.88 mm on 24th June followed by rainfall of low magnitudes up to 30th June. This resulted in continuous rise of water level having peak value of 47.94 m on 30th June.

b) During July - 2011



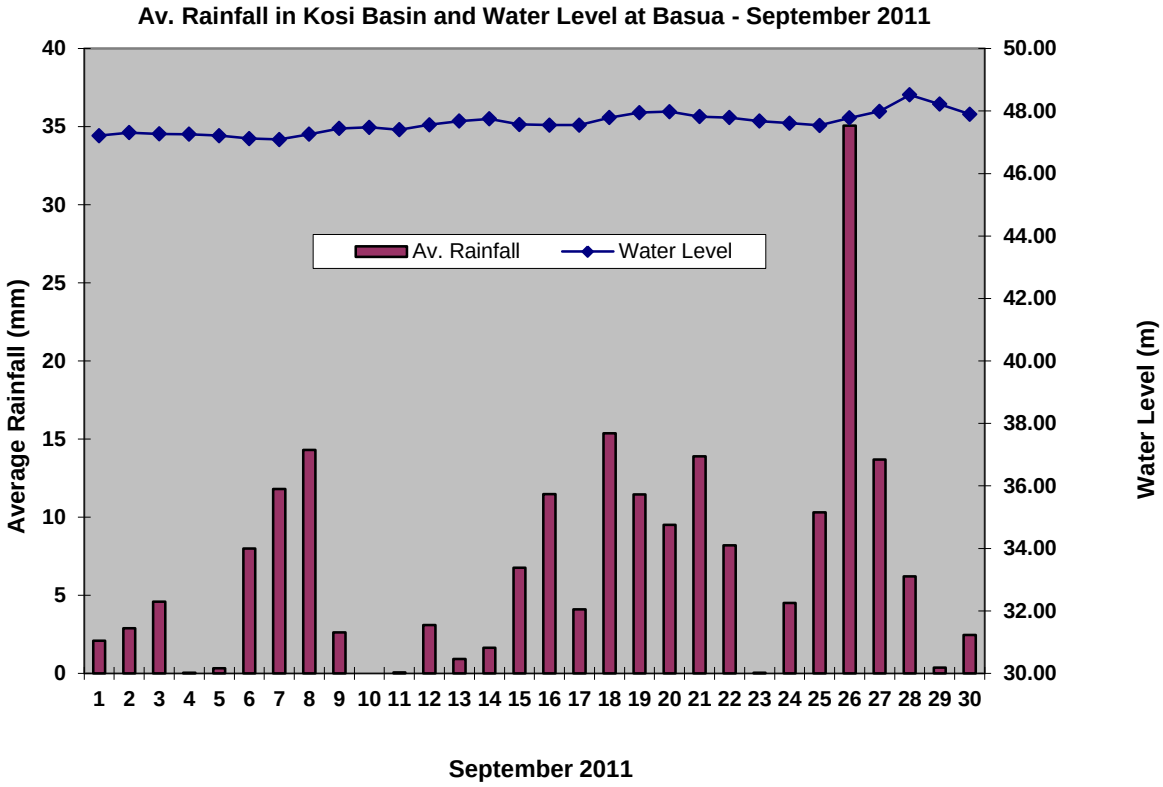
The average rainfall up to 3rd July was more than 20mm. A peak of 48.11m came on 2nd July and then receded till 9th July. Second spell of effective rainfall occurred between 11 to 14th July which resulted in the rising trend of the river at Basua and a peak of 48.18m on 16th July. The maximum average rainfall of 33.42mm occurred on 20th July in this month. This resulted in the maximum peak of 48.27 m on 22nd July, which was the highest value during July.

c) During August - 2011



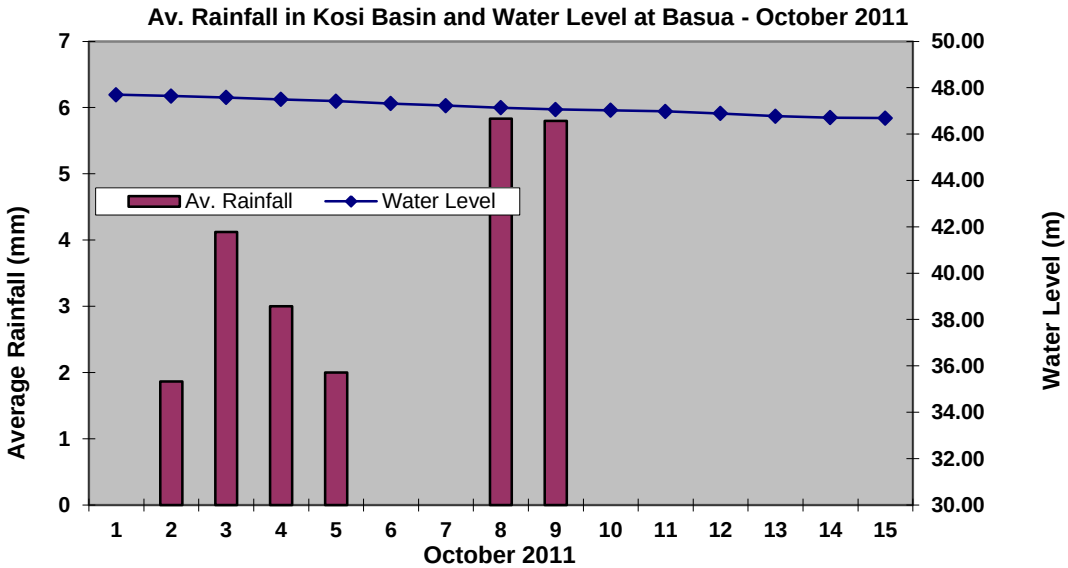
Similarly the average rainfall of 42.42 mm and 46.05mm occurred on 16th August and 17th August respectively which produced a peak of 48.53m on 18th August, which was the highest during the month of August. Thereafter, water level declined continuously up to the end of the month.

d) During September - 2011



In the first week of September, the water level remained constant. Thereafter water level continuously rose between 8th -20th September. An average rainfall of 35.06mm occurred on 26th September, which resulted in a peak of 48.52m on 28th September.

e) During October - 2011



In the month of October, water level continuously receded till the end of the flood season 2011. There was no significant rainfall during this period.

5.3.5 Conclusions

1. Water level rises and recedes as the magnitude of rainfall in basins rise or fall, of course, with a certain lead time. Nevertheless water level doesn't seem to have a very systematic relationship with average rainfall. The possible reason may be the inadequate number of rain gauge stations used to compute average rainfall, The available rain gauge stations are too less in number to capture the spatial variability of rainfall. Secondly, arithmetic mean doesn't hold well in hilly terrain. Isohyetal method with adequate number of rain gauge stations may improve the result.

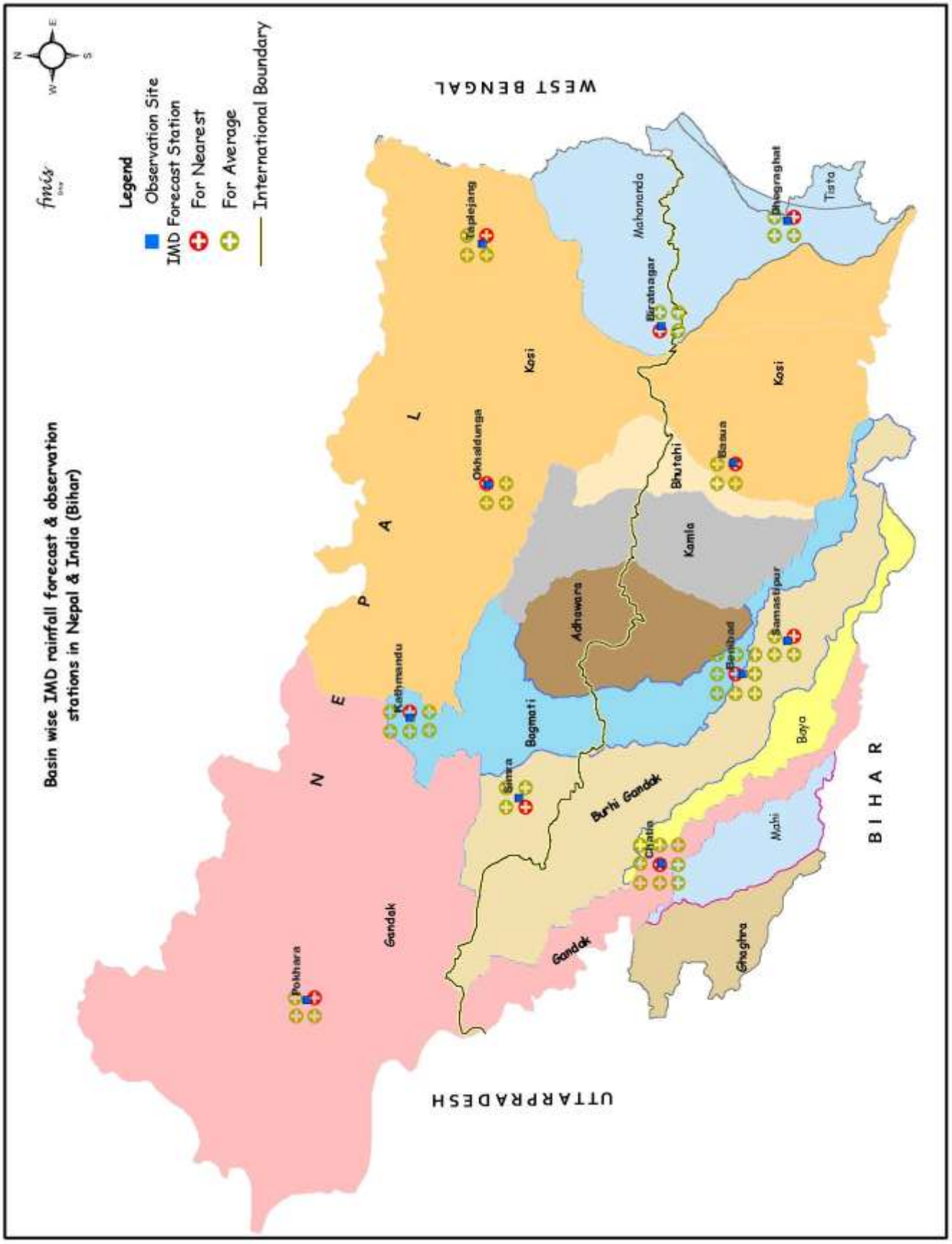
2. Rainfall - water-level relation is also bound to be affected by the control structures present upstream of the gauge sites on the rivers.

3. At Lalbegiaghat, Sonakhan, Jainagar and Basua lead time appears to be one day to two days. We can have more precise lead time if we use hourly or two-hourly data series in the analysis.

5.4 Rainfall Forecast

Under a MoU signed between FMISC, Bihar and IMD, New Delhi, the IMD has been providing rainfall forecast for an area between Latitude 25.53^0 N to 28.77^0 N and Longitude 83.24^0 E to 88.50^0 E. This area entirely covers the focus area of FMIS, catchments area of all rivers lying in Nepal and some adjoining area in Bihar as well as Nepal. The forecasts were done using the Weather Research and Forecasting (WRF) Model. It is a next-generation mesoscale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs. WRF model rainfall forecast, from IMD, Delhi is for 9x9 km resolution, i.e. total 1386 numbers of grids covering the area. It was done every day for the next three consecutive days separately i.e. for day1, day2 and day3.
Maximum value of forecasts for each river basins of the focus area of FMIS were extracted and provided in the Daily Flood Information Bulletin issued from the FMISC. These forecasts were used to acquire the availability of satellite images with NRSA, Hyderabad on the days likely to have critical rainfall.

A study was undertaken within FMIS to compare the 3 day WRF model forecast with the actual observed rainfall for Gandak, Burhi Gandak, Bagmati, Kosi and Mahanada basin. The forecast station that was chosen from 1386 grid stations are the one which lay within 4.5 km radius of the observation station both in Nepal and India (Bihar region). This was done by applying nearest neighborhood analysis in GIS environment. To better understand the relation between forecasted rainfall and observed rainfall, two different set of forecasted values were taken, one which lay within 4.5 km radius and another taking average of the stations lying nearby the observed station. Thus eleven forecast stations for one to one comparison and fifty six forecast stations were selected among the available data set of IMD for averaging the forecasted value and compare with nearest observed rainfall. To illustrate, the forecasted stations taken for study are being depicted in Map 5.4.1 and Table 5.4.1.below, which indicate the station name, basin name, region and position of the observation sites and WRF model stations.



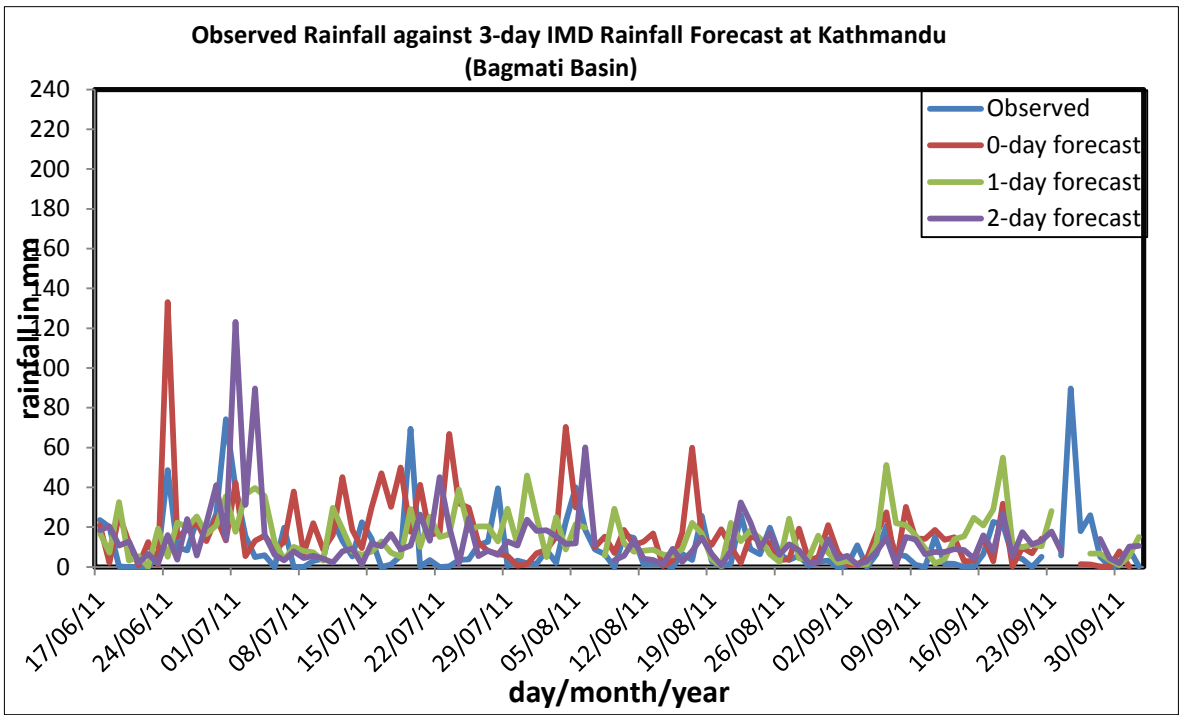
Map 5.4.1 Basinwise IMD rainfall forecast station and observation station in Nepal and India (Bihar)

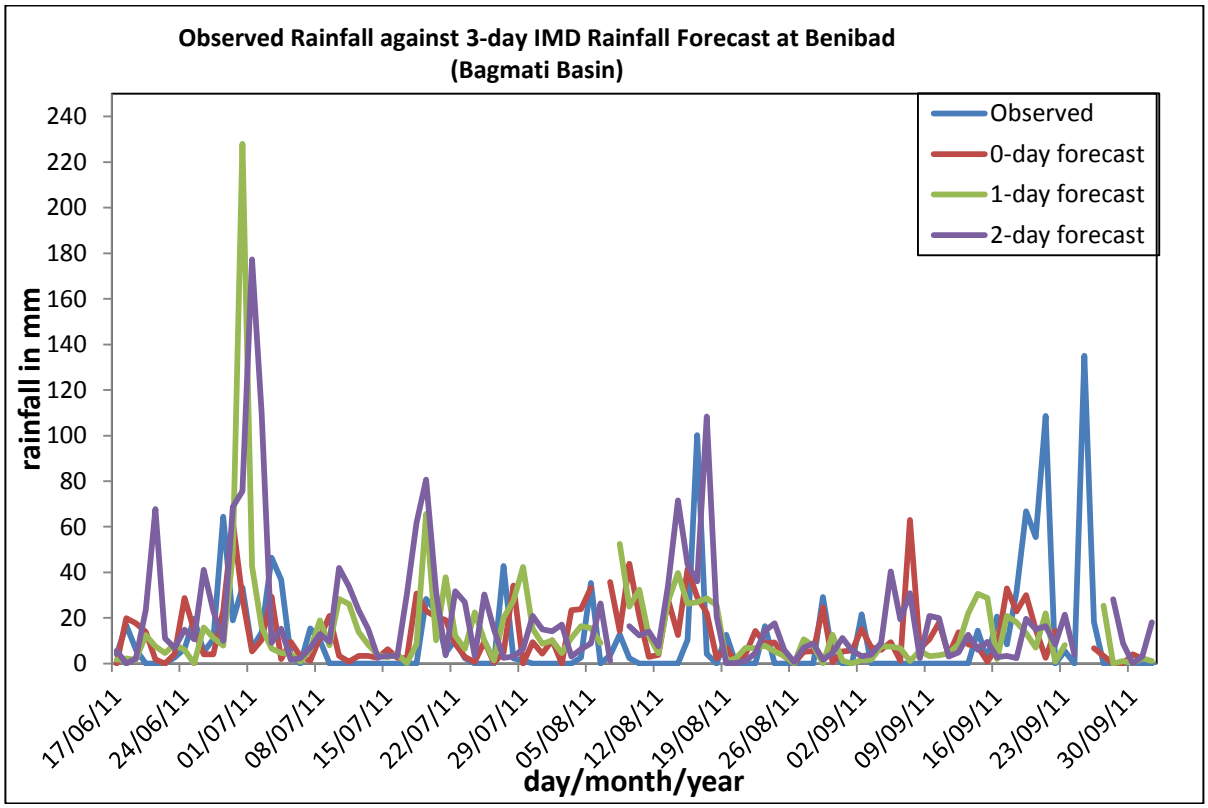
Table 5.4.1 : Names of Stations taken for comparison with WRF model forecast

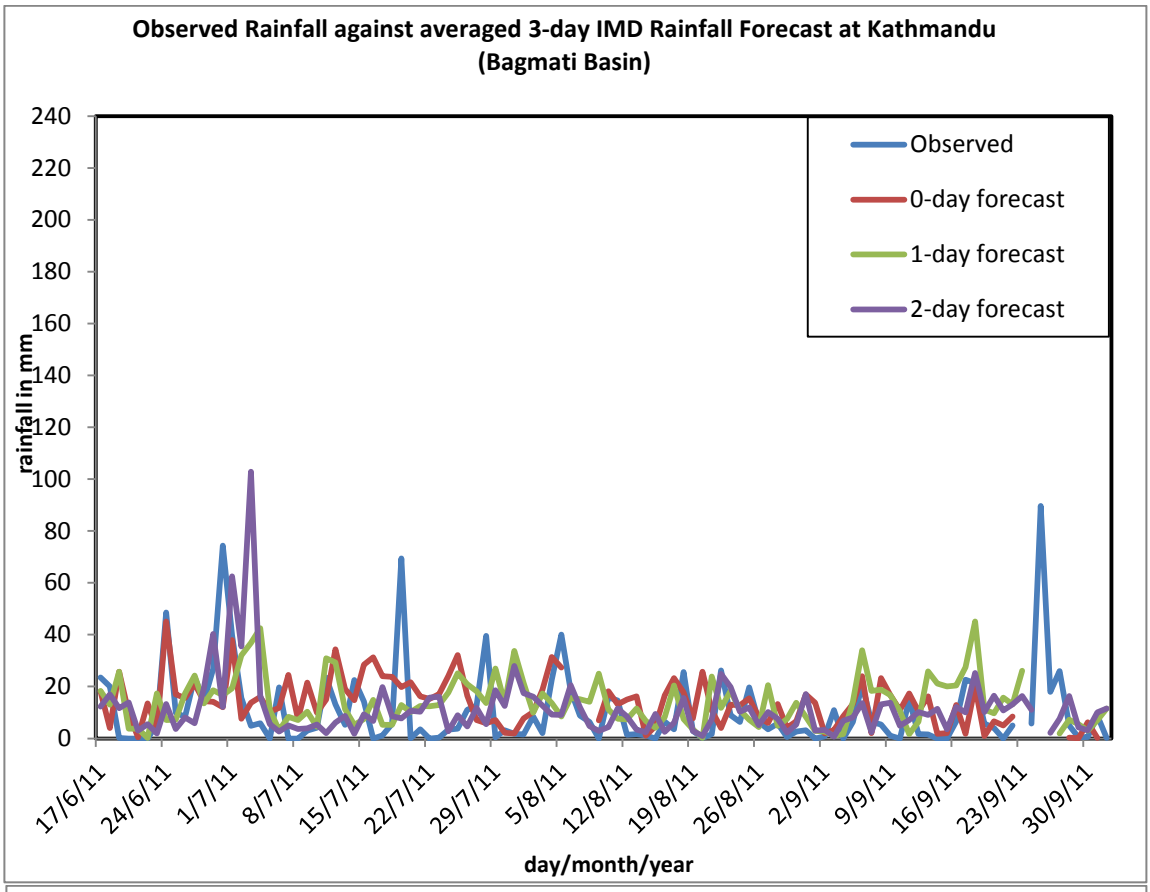
SN	Name of Basin	Region	Name of Station	Position	WRF model Station Name	Position	Forecast stations for averaging
1	Gandak	Nepal	Pokhara	84.00E 28.2N	F-659	84.015E 28.16N	F- 616, 615, 660, 659
		India (Bihar)	Chatia	84.66E 26.48N	F-949	84.62E 26.48N	F-906, 905, 904, 950, 949, 948, 994, 993, 942
2.	Burhi Gandak	Nepal	Simra	84.98E 27.17N	F-1088	84.93E 27.14N	F-1089, 1088, 1133, 1132
		India (Bihar)	Samastipur	85.74E 25.86N	F-1470	85.76E 25.83N	F-1427,1426, 1471, 1476
3.	Bagmati	Nepal	Kathmandu	85.37E 27.7N	F-1314	85.4E 27.69N	F-1271, 1270, 1269, 1315, 1314, 1313
		India (Bihar)	Benibad	85.58E 26.08N	F-1385	85.58E 26.11N	F-1342, 1341, 1340, 1386, 1385, 1384, 1430, 1429, 1428
4.	Kosi	Nepal	Taplejung	87.67E 27.35N	F-2410	87.70E 27.32N	F-2367, 2366, 2411, 2410
		Nepal	Okhaldunga	86.5E 27.32N	F-1838	86.50E 27.32N	F- 1794, 1793, 1838, 1837
		India (Bihar)	Basua	86.60E 26.12N	F-1869	86.6E 26.11N	F-1826, 1825, 1870, 1869
5.	Mahananda	Nepal	Biratnagar	87.27E 26.48N	F-2181	87.24E 26.48N	F- 2181, 2180, 2225, 2224
		India (Bihar)	Dhengraghat	87.78E 25.86N	F-2438	87.8E 25.83N	F- 2395, 2394, 2439, 2438

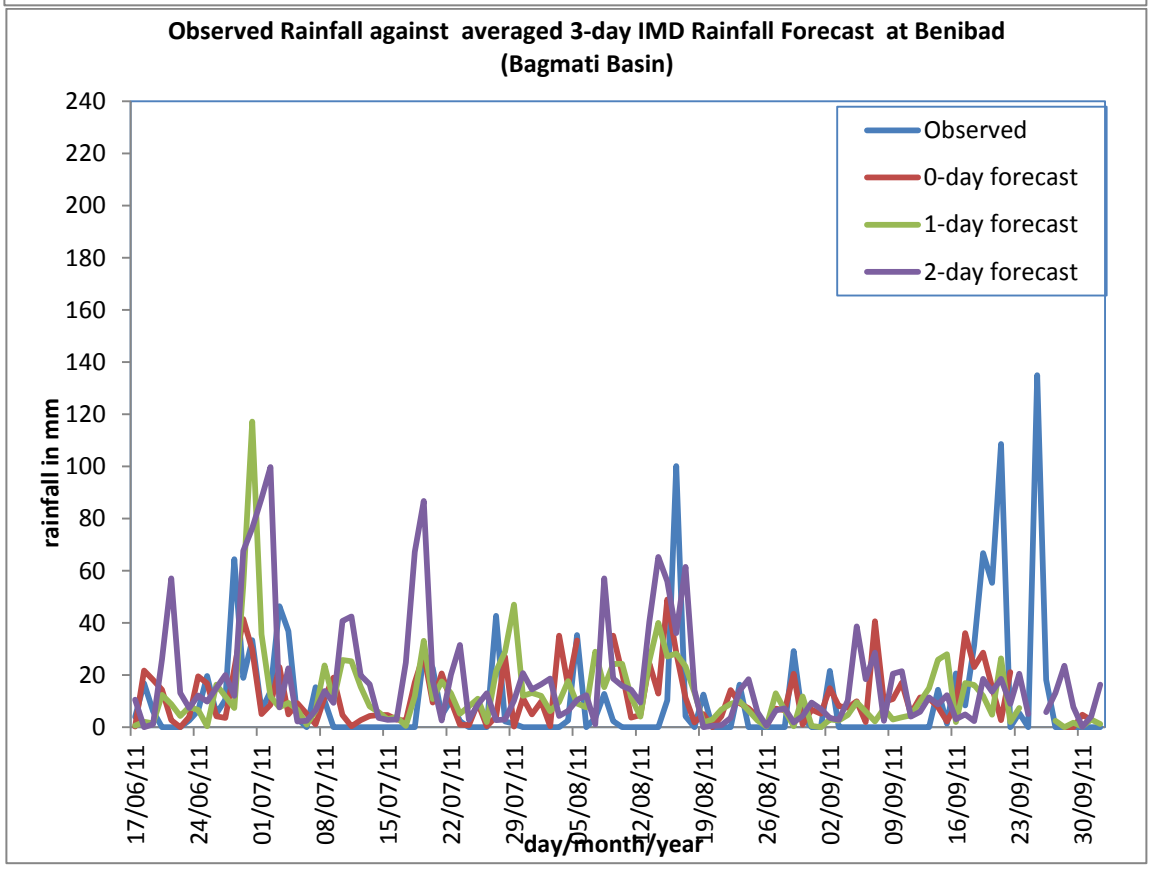
From the graphs and correlation, coefficients for all the stations show very poor relation between the forecasted and observed rainfall. More or less both in Nepal and Bihar the model result was far from what was observed.

A Sample graph for Bagmati Basin is included in this report.






Observed Rainfall against averaged 3-day IMD Rainfall Forecast at Kathmandu
(Bagmati Basin)
rainfall in mm
240
220
200
180
160
140
120
100
80
60
40
20
0
Observed
0-day forecast
1-day forecast
2-day forecast
17/6/11
24/6/11
1/7/11
8/7/11
15/7/11
22/7/11
29/7/11
5/8/11
12/8/11
19/8/11
26/8/11
2/9/11
9/9/11
16/9/11
23/9/11
30/9/11
day/month/year


Observed Rainfall against averaged 3-day IMD Rainfall Forecast at Benibad
(Bagmati Basin)
rainfall in mm
240
220
200
180
160
140
120
100
80
60
40
20
0
Observed
0-day forecast
1-day forecast
2-day forecast
17/06/11
24/06/11
01/07/11
08/07/11
15/07/11
22/07/11
29/07/11
05/08/11
12/08/11
19/08/11
26/08/11
02/09/11
09/09/11
16/09/11
23/09/11
30/09/11
day/month/year

The correlation coefficient between the observed rainfall and 3- day forecast is tabulated below:

Table 5.4.2 Nearest forecast station vs. observed station

SN	Name of Basin	Region	Name of Station	Correlation coefficient		
				0-day	1-day	2-day
1	Gandak	Nepal	Pokhara	0.26	0.32	0.14
		India (Bihar)	Chatia	0.36	0.33	.010
2.	Burhi Gandak	Nepal	Simra	0.28	0.20	0.21
		India (Bihar)	Samastipur	0.20	0.34	0.13
3.	Bagmati	Nepal	Kathmandu	0.25	0.24	0.23
		India (Bihar)	Benibad	0.25	0.18	0.06
4.	Kosi	Nepal	Taplejung	0.05	0.16	0.08
		Nepal	Okhaldunga	0.18	0.21	0.24
		India (Bihar)	Basua	0.22	0.25	0.57
5.	Mahananda	Nepal	Biratnagar	0.11	0.09	0.14
		India (Bihar)	Dhengraghat	0.34	0.02	0.19

Table 5.4.3 Average of nearest forecast station vs. observed station

SN	Name of Basin	Region	Name of Station	Correlation coefficient		
				0-day	1-day	2-day
1	Gandak	Nepal	Pokhara	0.34	0.28	0.21
		India (Bihar)	Chatia	0.33	0.28	0.19
2.	Burhi Gandak	Nepal	Simra	0.34	0.25	0.31
		India (Bihar)	Samastipur	0.29	0.29	0.18
3.	Bagmati	Nepal	Kathmandu	0.29	0.09	0.15
		India (Bihar)	Benibad	0.29	0.22	0.10
4.	Kosi	Nepal	Taplejung	0.07	0.15	0.05
		Nepal	Okhaldunga	0.35	0.15	0.14
		India (Bihar)	Basua	0.24	0.25	0.58
5.	Mahananda	Nepal	Biratnagar	0.15	0.08	0.17
		India (Bihar)	Dhengraghat	0.44	0.05	0.26

Conclusion

One can conclude from the preceding paragraphs that the WRF model rainfall forecast still needs improvement to catch the trend. The correlation table also shows that very poor correlation between the forecasted and observed rainfall exists. In general the forecasted values and the observed values are not in agreement and varying widely. The average forecast gave no better match. At times the trends are matching but absolute values are not matching at all. This aspect has to be looked upon by the model team as FMISC plans to improve the lead time of flood forecast using rainfall forecast as one of the inputs.

5.5 Satellite based analysis of Flood Impact

This year there was no major flood event, hence no major inundation or breach are reported. Floods in South Bihar plains due to Sone and Ganga during 2011 monsoon kept the cell at its toe. FMIS customized the inundation layers provided by NRSA under National Disaster Management Programme (NDMSP)

RADARSAT images covering the AOI were obtained during the flood season to view the flood impact. These images were procured and primarily processed under national disaster management support program (DMSP) by NRSC, Hyderabad, and then given to the Flood Management Improvement Support Center, Patna where value addition was done and disseminated to the user departments: Water Resources, Disaster Management, and Agriculture Departments. The maps depict the extent of flood inundation. The statistics elaborate the number of blocks / villages under inundation, population, and area affected etc.

Since FMIS is having Spatial database for only 11 districts of North Bihar (Focus Area Phase-I) our study are limited to these districts only.

Details of the satellite data acquired are as mentioned in the following table.

SL. No	Date of Satellite data Acquired	Date of satellite data received / product Dissemination	Type of Satellite/ Sensor	Trigger / Incidence
1	02-Jul-11	04-Jul-11	Radarsat-1	Flood Inundation in North Bihar
2	02-Jul-11	06-Jul-11	Radarsat-2	Flood Inundation in North Bihar
3	05-Jul-11	06-Jul-11	Radarsat-2	Flood Inundation in North Bihar
4	09-Jul-11	11-Jul-11	Radarsat-1 RISAT-2	Flood Inundation in North Bihar
5	19-Jul-11	20-Jul-11	Radarsat-2	Flood Inundation in North Bihar
6	29-Jul-11	02-Aug-11	Radarsat-2	Flood Inundation in North Bihar
7	02-Aug-11	02-Aug-11	Radarsat-1	Flood Inundation in North Bihar
8	06-Aug-11	07-Aug-11	Radarsat-2	Flood Inundation in North Bihar
9	10-Aug-11	11-Aug-11	Radarsat-1	Flood Inundation in North Bihar
10	12-Aug-11	14-Aug-11	Radarsat-2	Flood Inundation in North Bihar

SL. No	Date of Satellite data Acquired	Date of satellite data received / product Dissemination	Type of Satellite/ Sensor	Trigger / Incidence
11	17-Aug-11	19-Aug-11	Radarsat-1	Flood Inundation in North Bihar
12	20-Aug-11	20-Aug-11	Radarsat-2	Flood Inundation in North Bihar
13	22-Aug-11	23-Aug-11	Radarsat-2	Flood Inundation in North Bihar
14	24-Aug-11	25-Aug-11	Radarsat-1	Flood Inundation in North Bihar
15	26-Aug-11	26-Aug-11	Radarsat-1	Flood Inundation in North Bihar
16	29-Aug-11	30-Aug-11	Radarsat-2	Flood Inundation in North Bihar
17	02-Sep-11	02-Sep-11	Radarsat-1	Flood Inundation in North Bihar
18	03-Sep-11	05-Sep-11	Radarsat-1	Flood Inundation in North Bihar
19	05-Sep-11	06-Sep-11	Radarsat-1	Flood Inundation in North Bihar
20	10-Sep-11	11-Sep-11	Radarsat-1	Flood Inundation in North Bihar
21	28-Sep-11	04-Oct-11	Resourcesat-2AWiFS	Flood Inundation in North Bihar
22	30-Sep-11	04-Oct-11	IRS P6 AWiFS	Flood Inundation in North Bihar
23	01-Oct-11	04-Oct-11	Radarsat-2	Flood Inundation in North Bihar
24	04-Oct-11	05-Oct-11	Radarsat-1	Flood Inundation in North Bihar
25	09-Oct-11	10-Oct-11	Radarsat-2	Flood Inundation in North Bihar

Total no. of layers received during the flood season 2011 – 25 no.

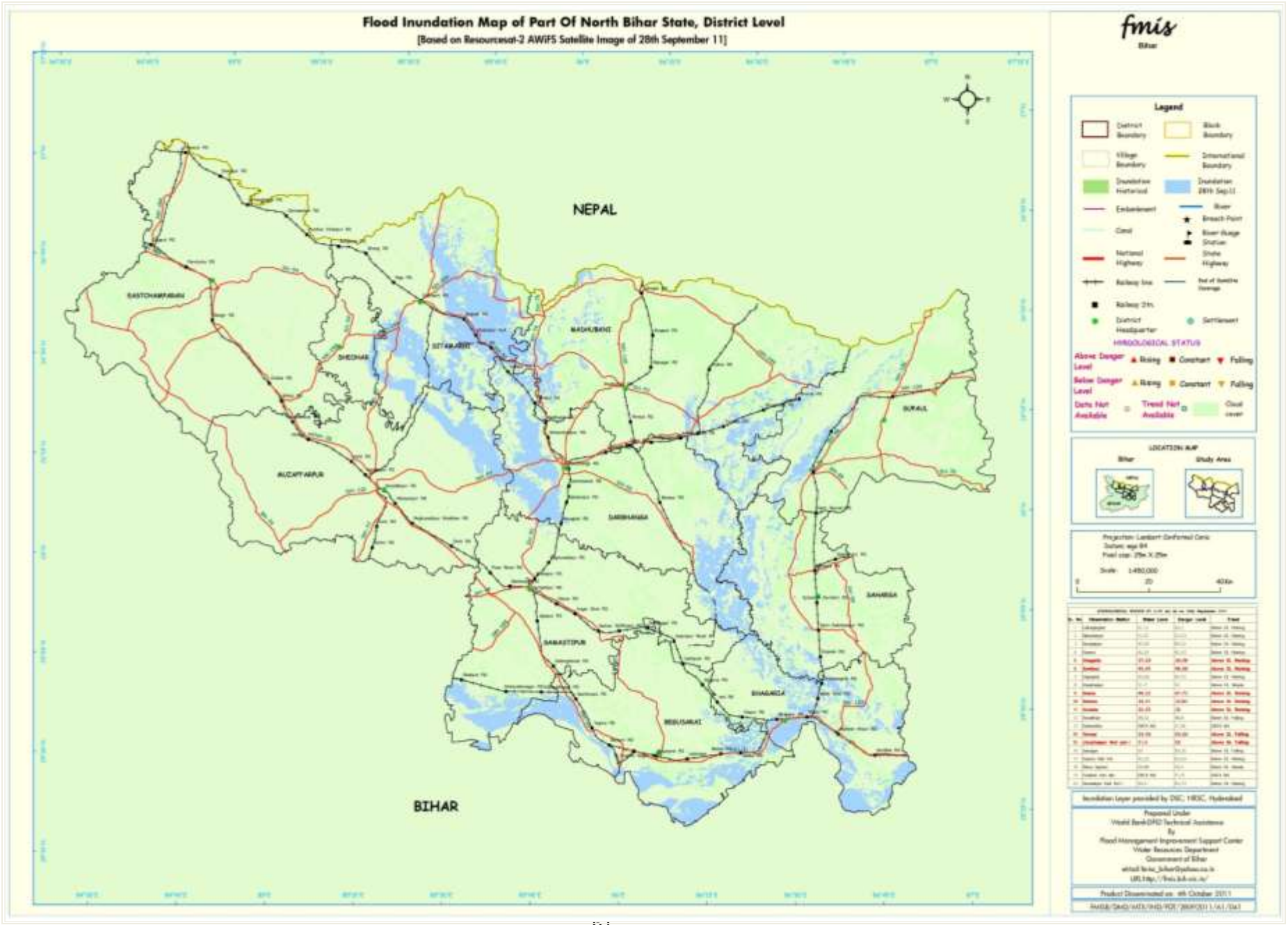
5.5.1 Value Added Inundation Maps

Based on our past experience of last four flood seasons we have tried to make our maps more useful to a greater number of users with varied interest and responsibilities. The maps are customized showing the administrative boundaries, important settlements, location of gauge sites; both for water level and rainfall along with trend of water level; relief camps as well as location of sites where roads have been overtopped by flood waters. Also for more value addition we have enriched our Geo database from various sources. The Information Products are found to be very useful in planning movement of officials and material for flood affected areas. The same information is posted over our website as soon as the product is ready.

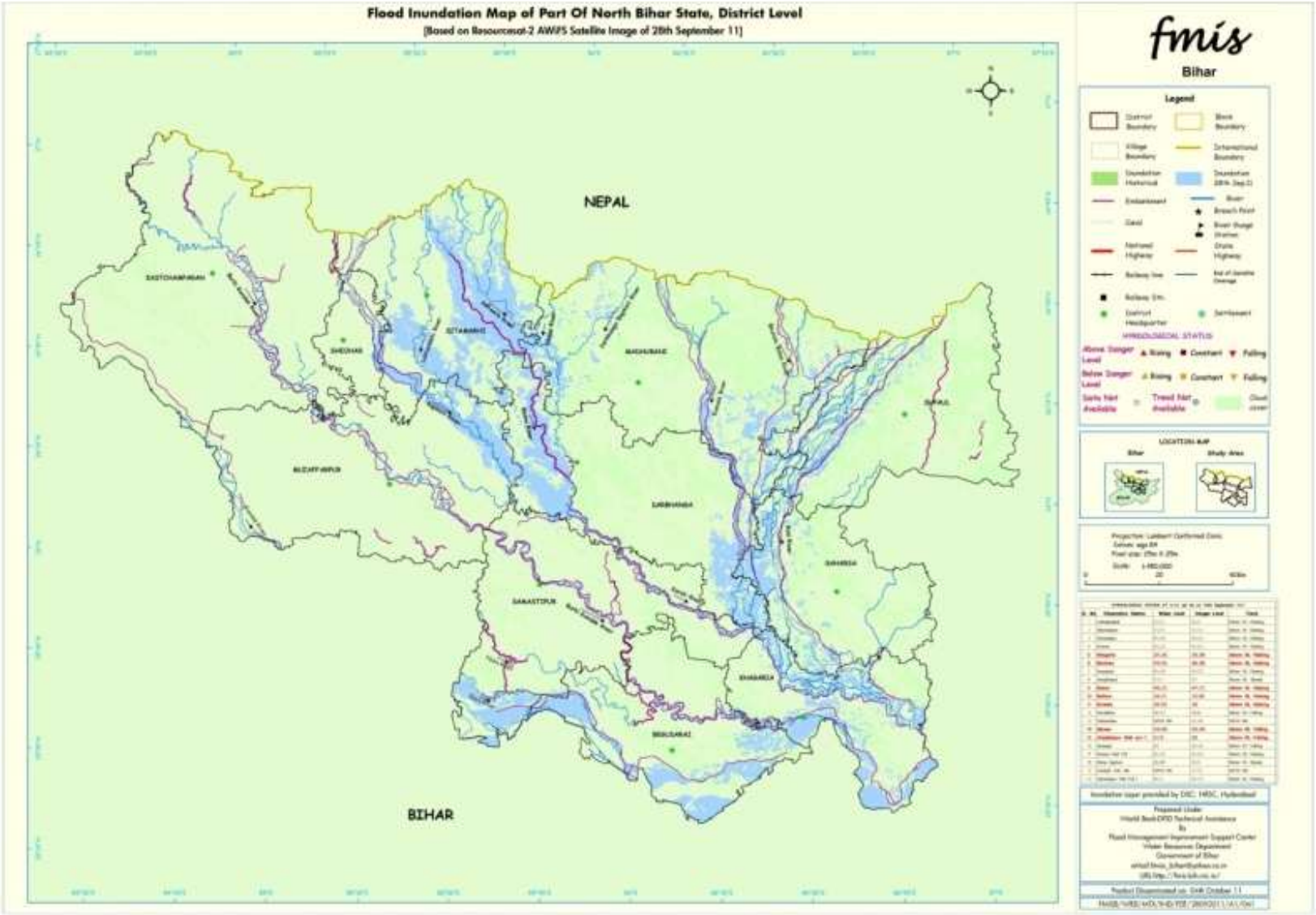
The customized products prepared in flood season 2011 for uses for different stakeholders such as Water Recourses Department, Disaster Management Department, Bihar Rajya Pul Nirman Nigam and Agriculture Department are as below:

- Flood Inundation Maps
- Area Specific Maps
- During Flood river status maps based on MODIS data
- Post Flood river status maps based on MODIS data
- River specific maps for Kosi based on MODIS data
- Probable Inundation Map

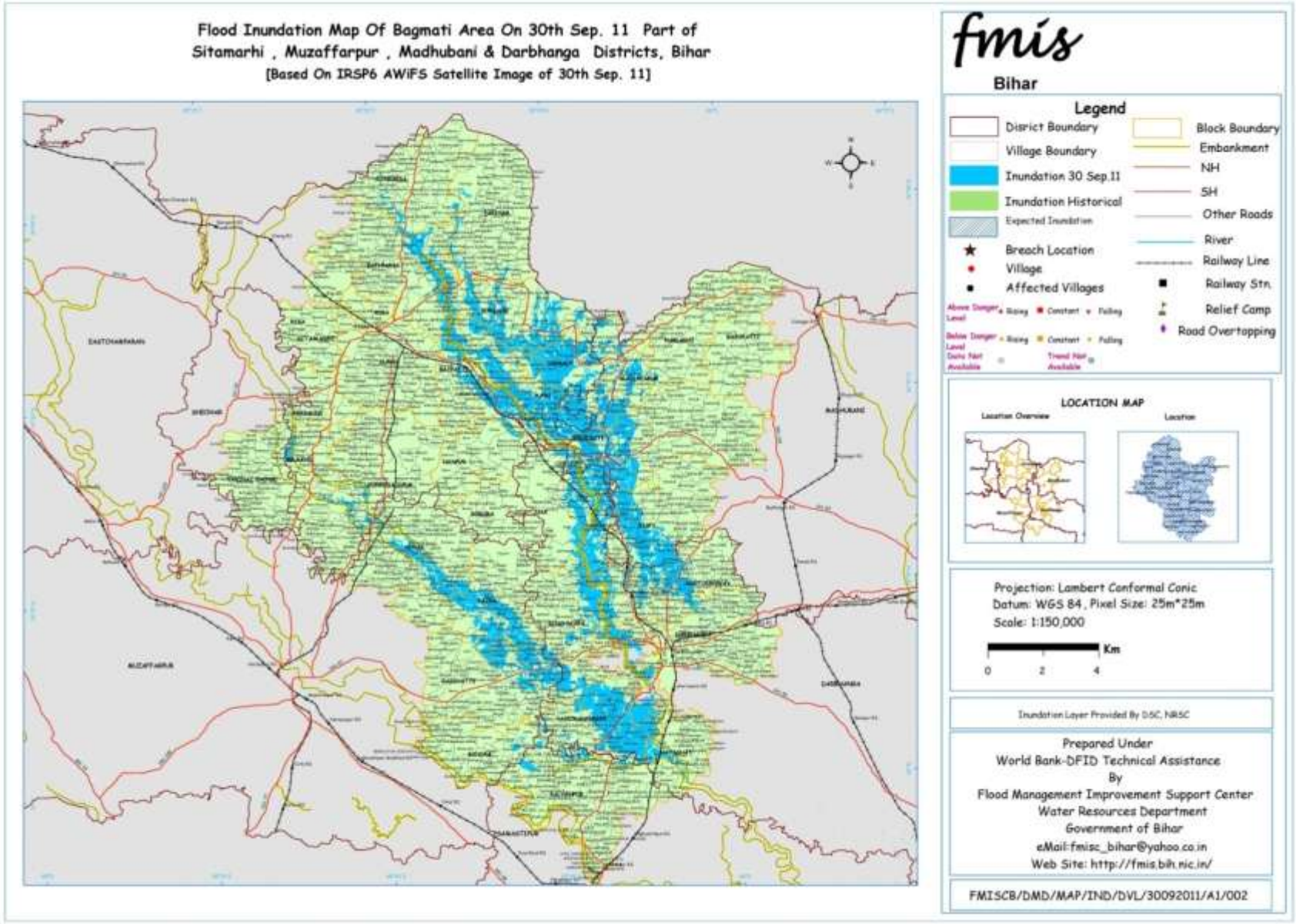
Map 5.5.1.1 Inundation map customized for DMD part of north Bihar showing district boundaries (based on Radarsat-2 AWIFS satellite image dated 28th Sep. 2011)



Map 5.5.1.2 Inundation map customized for WRD part of north Bihar showing rivers, embankment and hydrological status (based on Radarsat-2 AWIFS satellite image dated 28th Sep. 2011)



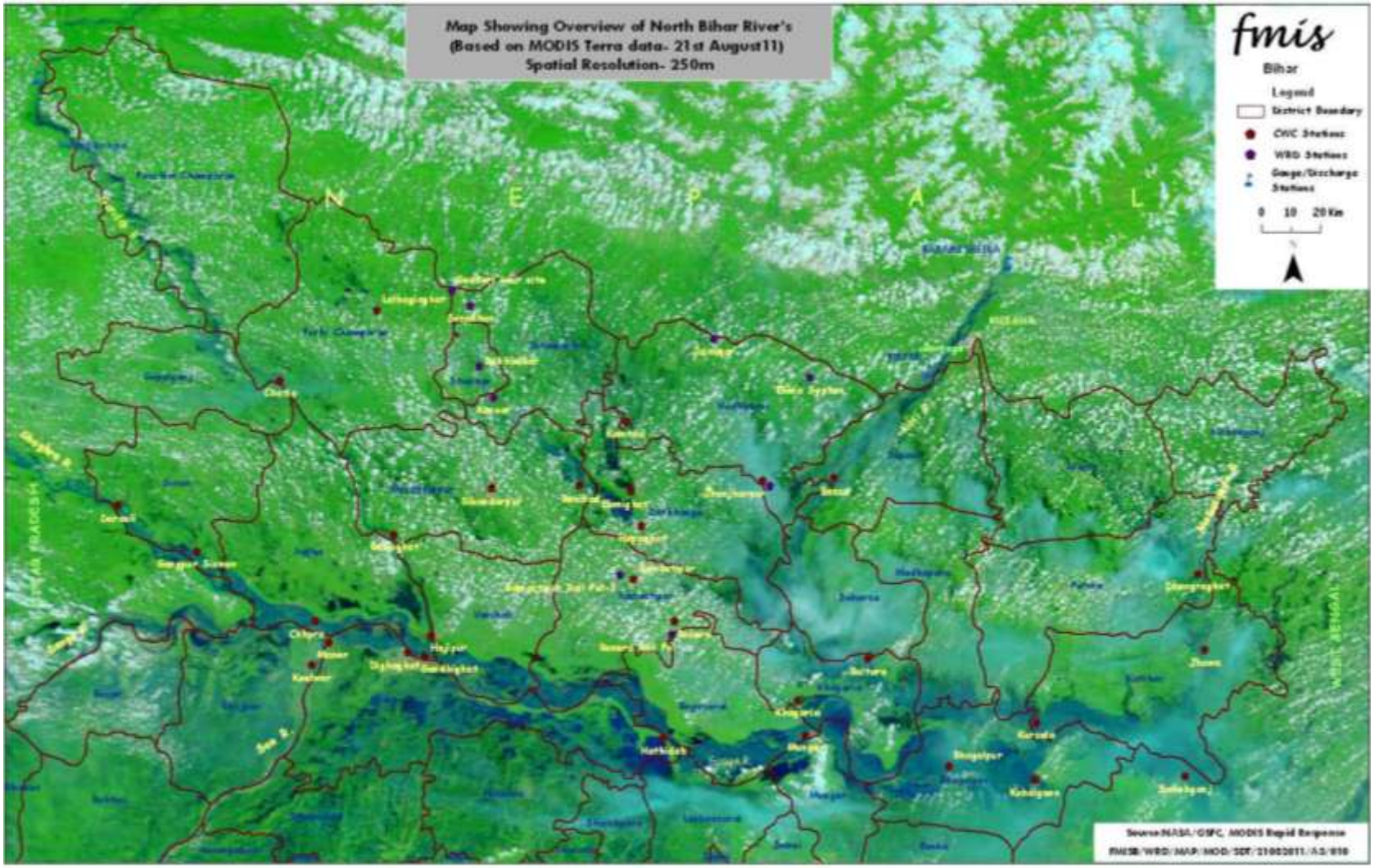
Map 5.5.1.3 Area specific Inundation map customized up to village level details of the Administrative units along with rivers, embankment, NH, SH, other roads, Rail line & its stations and hydrological status of this particular flood trigger in part of north Bihar dated on 30th Sep. 2011 based on IRS P6 AWiFS inundation layer.



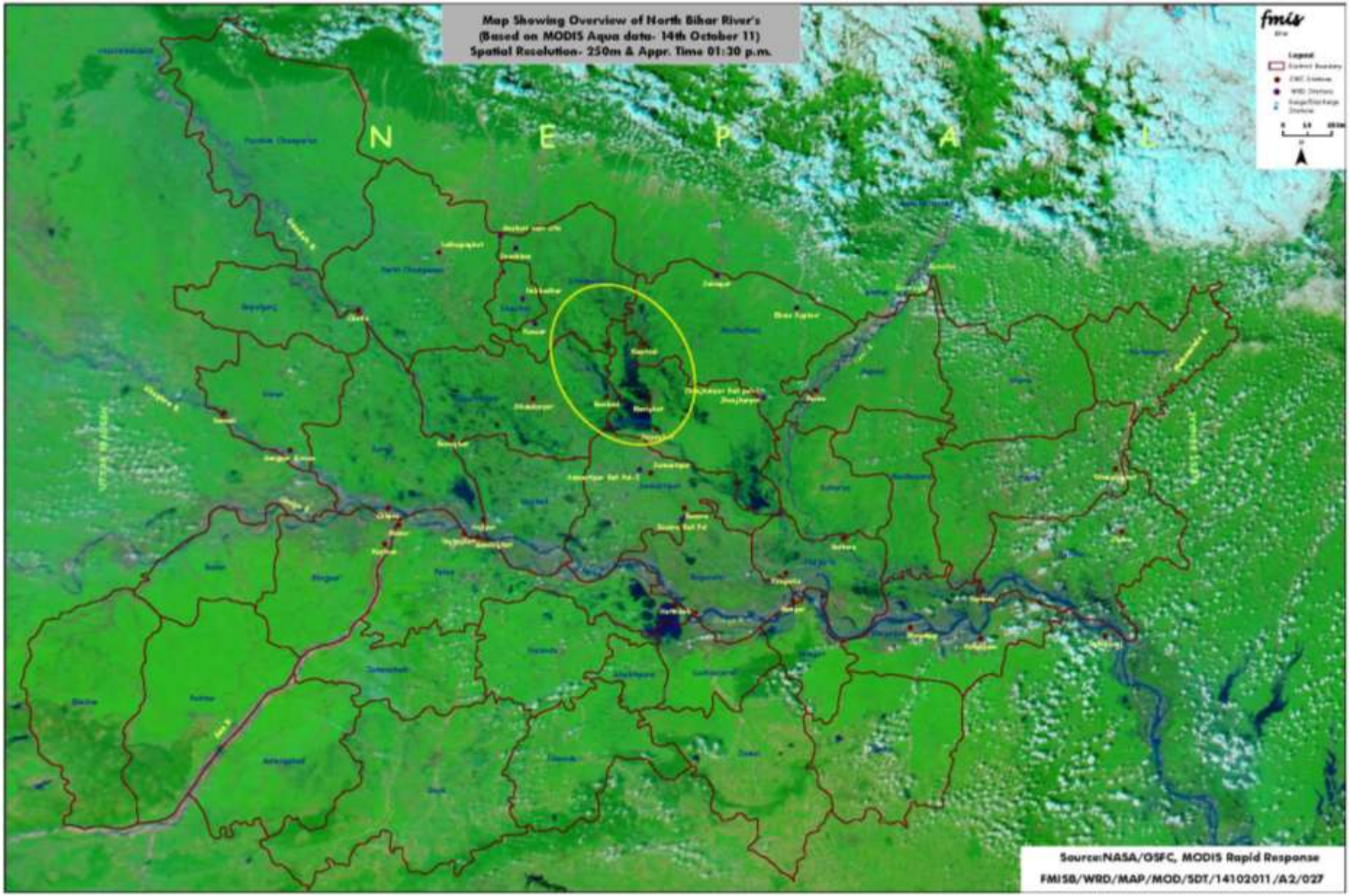
Other customized products:

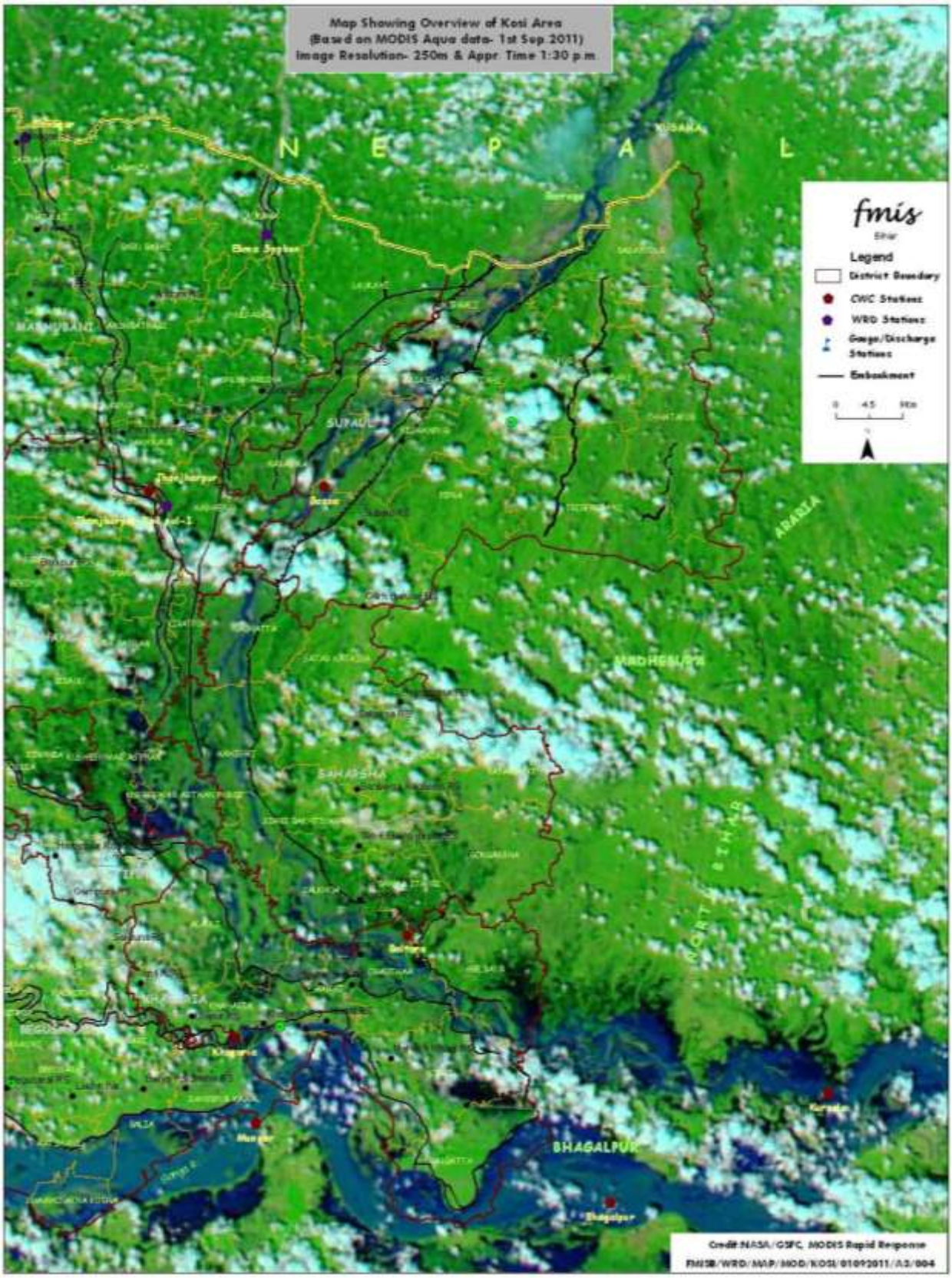
- Based on Moderate Resolution Imaging Spectroradiometer(MODIS) satellite data: We are regularly monitoring the river status with the help of MODIS satellite data of "during flood" and "post flood" also. This data is basically used for the over view of the big area, showing the river system of the North Bihar.

Map 5.5.1.4 Map showing overview of North Bihar Rivers during flood Season 2011, based on MODIS 21st August 2011.

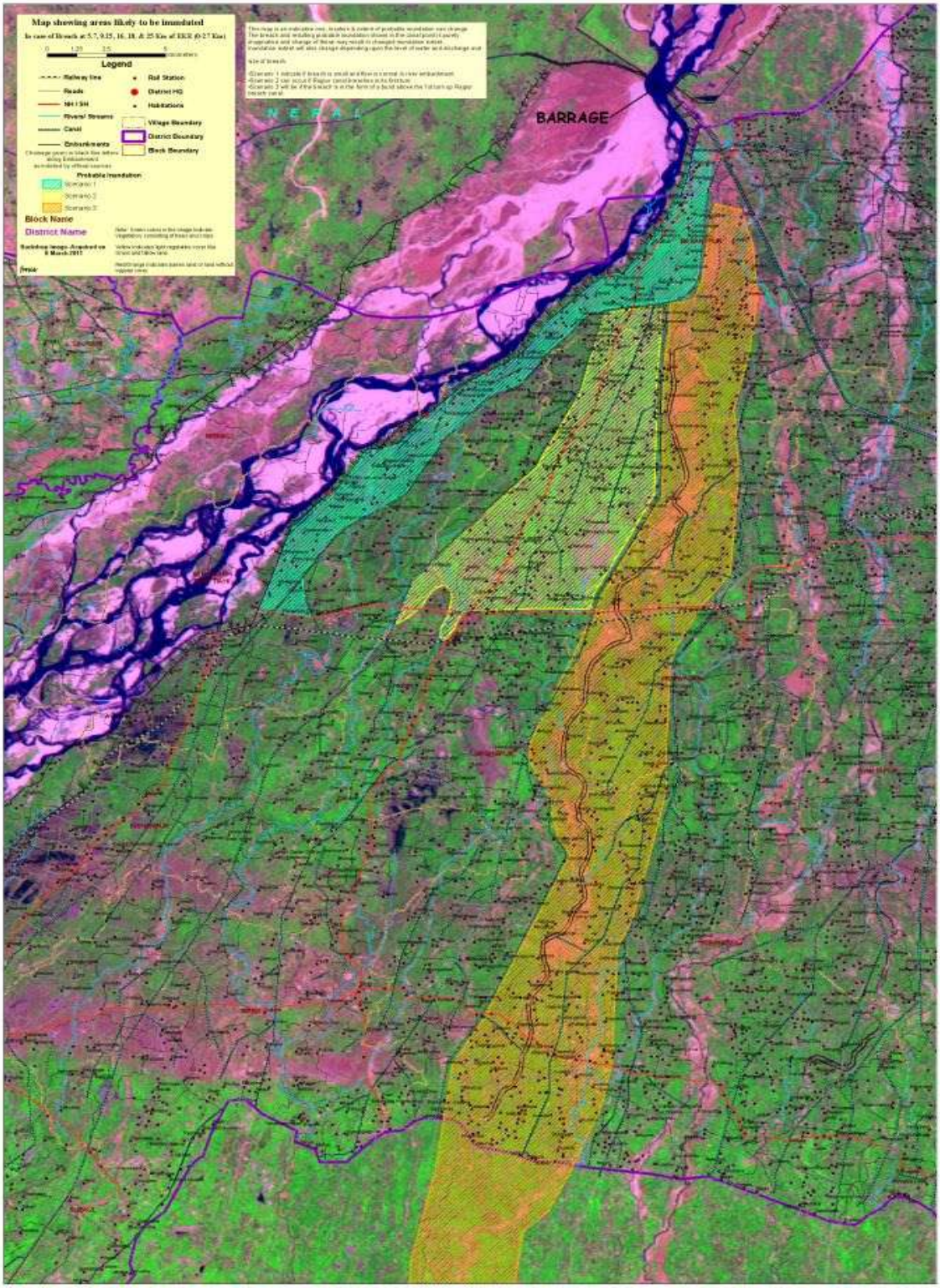


Map 5.5.1.5 Map showing overview of North Bihar Rivers after flood Season 2011, based on MODIS 14th October 2011.



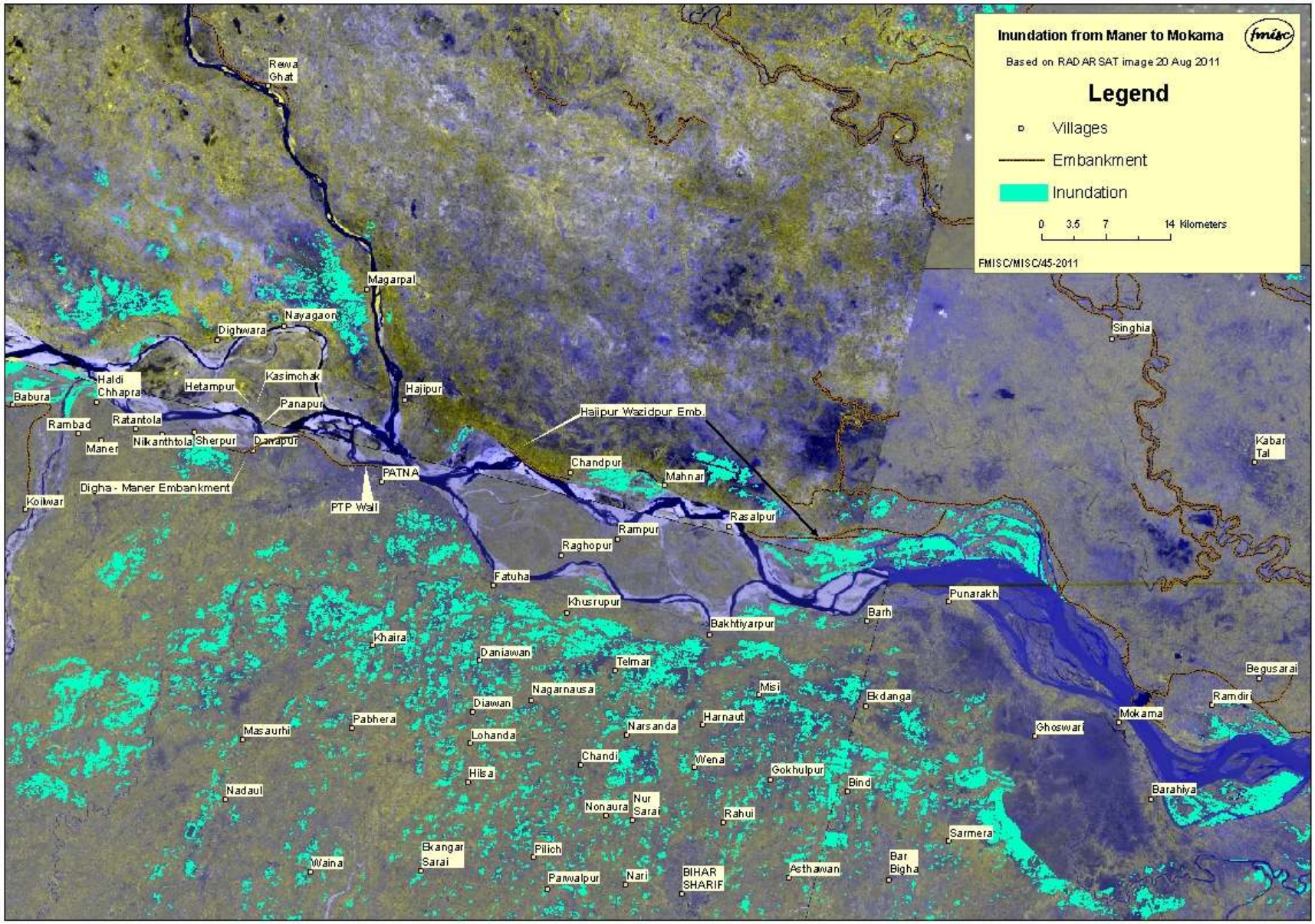


Map 5.5.1.6 Kosi as on 1st September 2011.



Map 5.5.1.7 – Map showing probable inundation in case of breach at reported vulnerable reaches of E. Kosi Embankment.

Map 5.5.1.8 – Map showing flood inundation in South Bihar Plains from Maner to Mokama as on 20th August 2011.



5.5.2 Maximum Inundation Extent Map

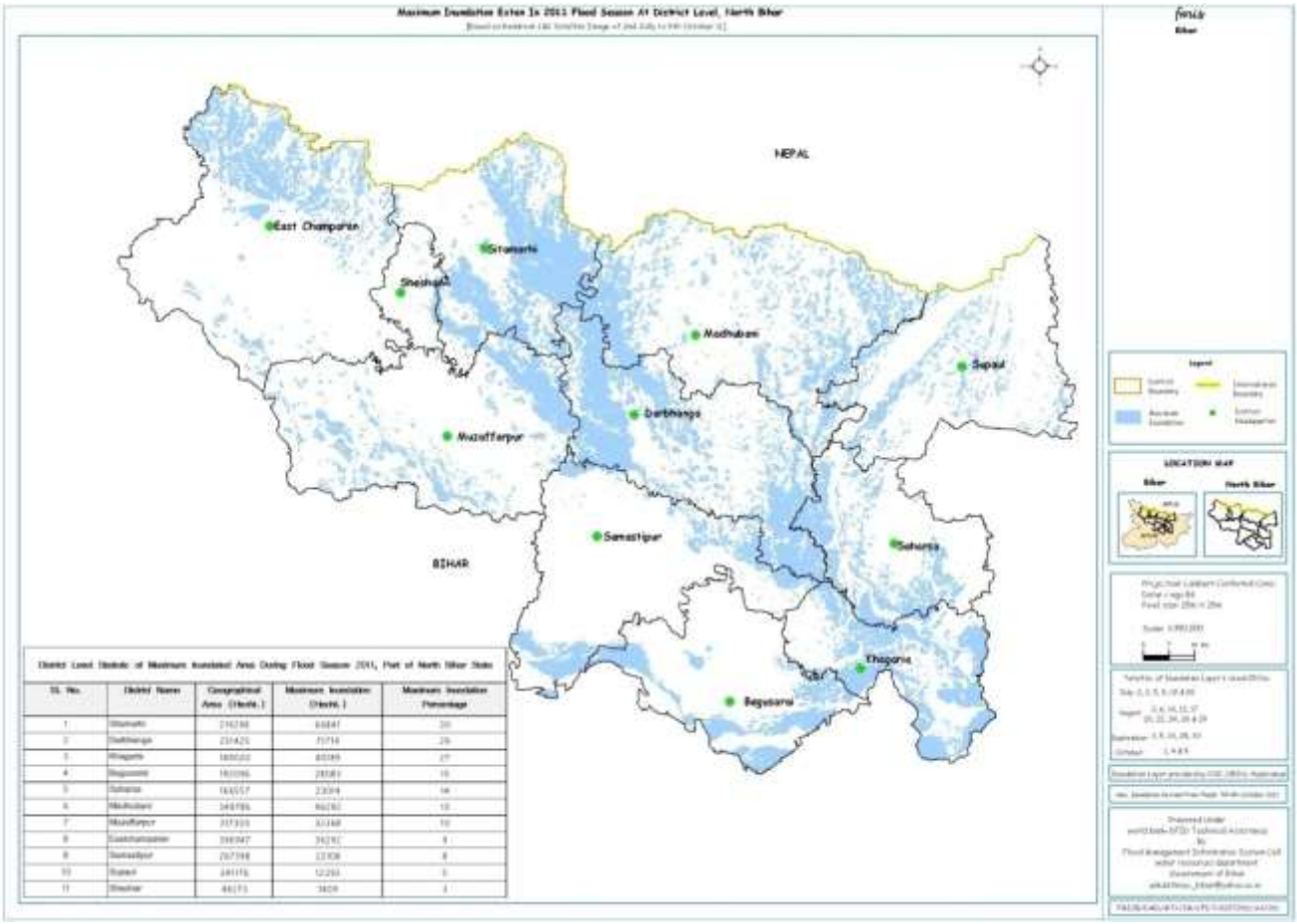
Maximum Inundation Extent Map was derived from RADARSAT data from 02nd July to 09th October. 25 numbers of scenes of the focus area were taken to prepare the layers of inundation maps. These layers were used to generate the maximum extent of inundation during the flood season 2011. The map shows the area was flooded at least once in the given period (02nd July to 09th October). The maps were prepared for Water Resources Department and Disaster Management Department. Department of Agriculture can also use these map for assessing water logged area and crop planning.

Statistics of Inundated Geographic Area of Part of Bihar state on till 09th October 2011are given in the Table 5.5.2.1 below:

Table 5.5.2.1

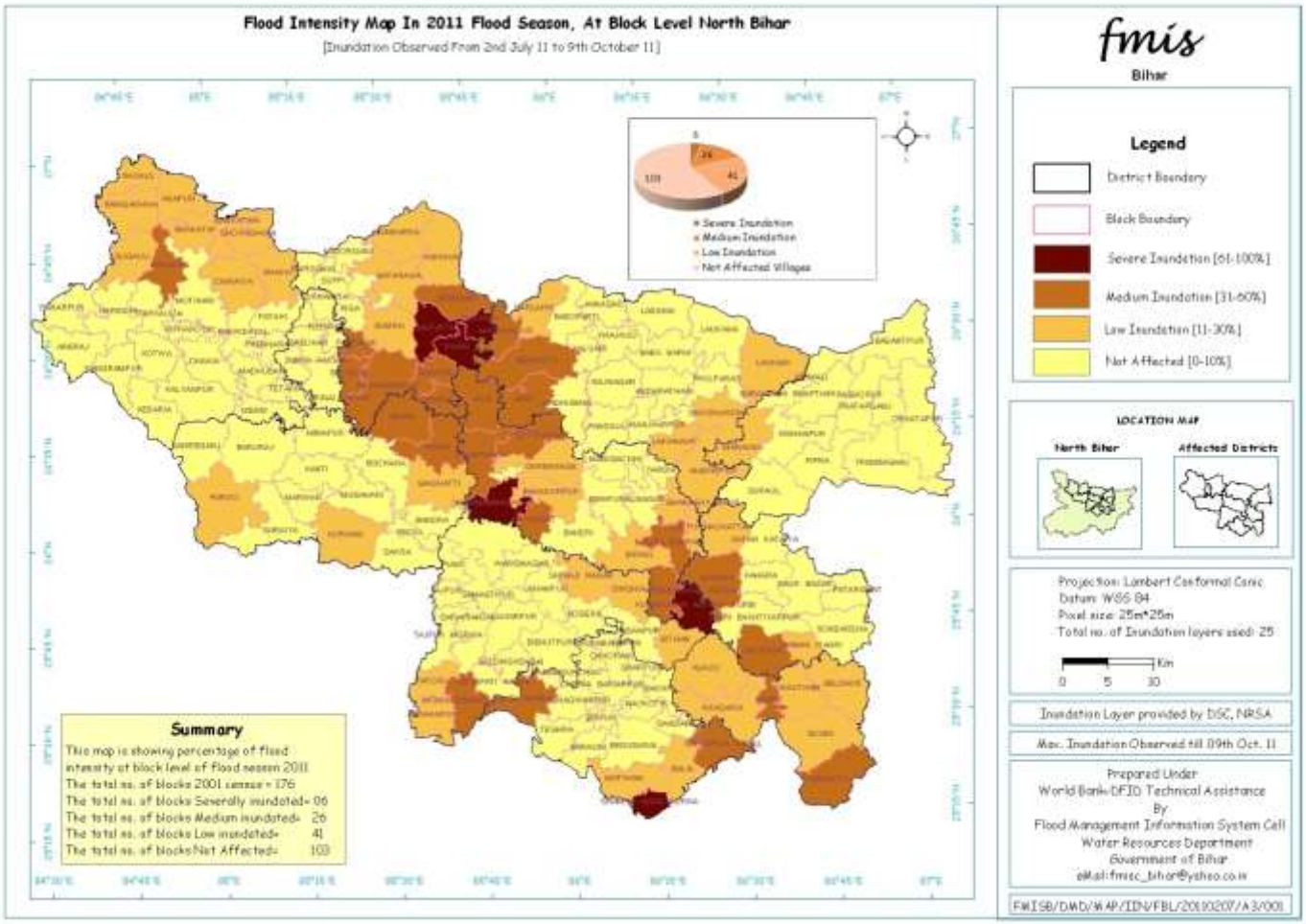
District Level Statistic of Maximum Inundated Area During Flood Season 2011, Part of North Bihar State				
Sl. No.	**District Name**	**Geographical Area (Hecht.)**	**Maximum Inundation (Hecht.)**	**Maximum Inundation Percentage**
1	Sitamarhi	219298	66841	30
2	Darbhanga	251425	71719	29
3	Khagaria	149020	40189	27
4	Begusarai	192096	28083	15
5	Saharsa	166557	23014	14
6	Madhubani	349786	46292	13
7	Muzaffarpur	317303	32368	10
8	Eastchamparan	396947	36292	9
8	Samastipur	267398	22108	8
10	Supaul	241176	12292	5
11	Sheohar	44273	1409	3

Map 5.5.2.1 Maximum inundation map of flood season 2011



5.5.3 Flood Intensity Map

The maps were prepared using the Radarsat scenes as referred in above paragraph. This has been prepared for district level and block level at the end of monsoon season 2011 as shown in Map 5.5.3.1



Map 5.5.3.1 Block level Flood Intensity Map of Flood Season 2011

6.0 Salient features of Bihar FMIS Phase-II (TF 096841)

FMIS Phase II: A proposal for FMIS Phase II for the Grant of nearly Rs. 11.92 crore (3.03 million US $) with extended focus area covering whole of North Bihar, with the objective of improved flood forecasting and early spatial warning etc. was submitted to the Bank via Department of Economic Affairs, Ministry of Finance, Govt. of India in June 2008. The Bank took up preparation of the project through its mission in April 2009 and extensive consultation with stakeholders & field visits were conducted by the Bank in this process. In the meantime DEA in April 2009 (letter no- F. No. 16/03/2008-FB-II dt 17.04.2009, serial no 5) downscaled the Grant request to US $ 1.5 million only with assurance to scale it up to the original request of 3.03 million US $ if the recipient shows good disbursement at a faster pace during project implementation. The project was then restructured by reducing the scope/ geographic coverage area of many activities to accommodate within this limited budget. The agreement for TA (Technical Assistance) of 1.5 Million US $ (nearly Rs. 675 lac) DFID, UK Grant was signed between DEA (Department of Economic Affairs), GOI and the World Bank on 31.05.2010 and administrative approval of Bihar Cabinet was received on 18.01.2011. Currently, it is scheduled to be completed by 31.12.2012.

Funding / Financing of the FMIS Ph –II Project

The total cost of the development of the project is estimated as Rs 825.00 lac out of which Rs. 675.00 (nearly US $ 1.5 million) would come from Technical Assistance (TA) from the World Bank and rest Rs. 150 lac would come from state contribution to the project. The State contribution includes Rs. 130.15 lac already disbursed from 01.07.2008 to 31.07.2010 to continue the functioning of the FMISC and Rs. 19.85 lac has been kept to obtain various satellite data from NRSC and for other miscellaneous expenditure.

Ph –II Project Components

The Technical Assistance has the following three components:

Component A: Institutional Strengthening for Flood Management

This component includes support for the institutional strengthening of FMIS Centre essential to achieve and sustain the aims of the project. The Centre would also act as focal point on flood information and analysis in the Water Resources Department (WRD), as well as links to stakeholder agencies (in particular, the Disaster Management Department). The support to be provided for strengthening would be setting up emergency flood control rooms, including office and equipment up gradation, improved connectivity, video conferencing facility, as well as training and other capacity building and moving to a comprehensive strategy for modernizing policy, institutional, and technical aspects of flood management in Bihar. A Panel of Experts will be constituted to help improve quality of the entire project, as well as special studies and international training. The two proposed focus areas are:

A1. Capacity Building and Training

i) This includes support for improving flood management through strengthening of FMIS Center by recruitment of specialist staff, office upgrading, equipment including connectivity upgrading, and incremental operational expenses, building on the current FMIS Centre, as a focal point to provide state-of-the-art flood information and analytical services to flood-related departments of GoB.

ii) Strengthening the Hydrology Directorate of Water Resources Department, through recruitment of specialist staff, office upgrading, equipment including connectivity upgrading, and incremental operational expenses, to improve their current activities and interface with the FMIS Center. In addition, WRD offices will be strengthened, including higher-level offices in flood-affected areas, and field offices in the targeted area of Bagmati-Adhwara Basin through office and equipment upgrading including connectivity, critical specialist staff and incremental office expenses.

A2 Flood management strategy and planning

An Integrated Flood Management Plan will be developed for the Bagmati Basin by considering flood issues with other interlinked water resources management issues. In addition, this activity would support special studies to upgrade flood management manuals and outline larger-scale institutional strengthening for the Water Resources Department.

Component B: Development of Flood Management Information Systems

This Component includes support for the development of a modern flood management information system for Bihar, with an initial demonstration in selected areas of the Bagmati-Adhwara basin. This also includes support for improving the spatial knowledge base for flood management, developing and using models for forecasting flood flow and inundation, and the establishment of a much-needed embankment asset management system. Support also provides for associated consultancies, surveys, satellite imagery and other data procurement, and related operating expenses. The proposed focus areas are:

B1 Improve Knowledge Base for Flood Management

This sub-component supports following activities to strengthen the knowledge base to improve flood management:

i) Support for critical topographic and other surveys (e.g. cross-sections/ longitudinal sections of embankments and river) in the focus areas of the Bagmati - Adhwara Basin.

ii) Support will be provided to immediately upgrade the inadequate and very outdated monitoring network for precipitation, flood flows, and sediment by setting up RTDAS (Real Time Data Acquisition System).

iii) Support will also be provided for the development of a satellite imagery-based spatial database covering flood-prone North Bihar.

B2 Improve Modeling/Analysis for Flood Warning
This activity supports

i) Flood Forecasting and Inundation Modeling in the Bagmati-Adhwara basin (enhancing the present system of stage-level warnings based on gauge-to-gauge correlation). Both traditional and innovative modeling approaches will be attempted.

ii) Studies on river course migration and analysis of flood hazard/risk/vulnerability.

B3 Establish an Embankment Asset Management System

The embankment system in North Bihar is extensive, but suffers from extensive problems of inadequate maintenance, exacerbated by the lack of any systematic inspection programs and techniques and data to assess current embankment status or prioritize embankment investments. This activity will support the development of a systematic Embankment Asset Management System (EAMS) for Bagmati-Adhwara basin supported by detailed modern surveys of the embankment status in the Bagmati-Adhwara basin that is partially embanked and where substantial investments for new embankments are planned.

Community participation for embankment surveillance and to update embankment safety information in the EAMS will be piloted.

Component C: Community-Based Flood Risk Management in Targeted Areas
This Component will include support for the planning and implementation of community-based flood management in selected areas of the Bagmati-Adhwara basin. This will include support for consultancies, communication systems, and associated operating expenses. The proposed focus areas are:

C1. Planning Community Outreach for Flood Management

This sub-component will support the planning for community outreach for effective flood management, focused on the situation on the ground in the targeted areas of the Bagmati-Adhwara Basin. Technical assistance will be provided to develop strategies to improve community awareness, preparedness, and response, including institutional arrangements and tools for improved early warning communication and dissemination and for community reporting of flood problems.

C2. Enhancing Community Participation for Flood Management

This sub-component will support the implementation of efforts to improve community participation for selected flood-prone areas of the Bagmati-Adhwara Basin. This will include support for technical assistance, communication tools, and community participation to demonstrate the “last mile” connectivity and involving the WRD, Disaster Management Department, District administration, and other institutions. Synergies with the existing Bank-financed Bihar Livelihoods Project are also being explored.

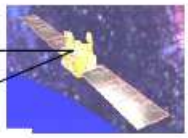
Current Status of FMIS Phase II:

Implementation of activities as per approved **procurement plan** is in progress. TORs of critical activities have been finalized and for other activities it is under preparation/ finalization. An updated & detailed status of different activities is attached.

Status of disbursement shows that as of now, the actual disbursement is Rs 1, 85, 73,839 (bottom of col. 8 of the attached table) which is nearly 27.5 % of Grant Amount and committed amount is Rs. 67,46,148 (bottom of col. 9). This adds up to Rs. 2,53,19,987 (bottom of col. 10) against Rs 6,75,00,000 (1.5 million US $) of DFID (WB) Grant which indicates 37.5 % financial commitment till date. By end of March 2012, we hope to commit additional Rs.195 lac (25 lac for equipments, 15 lac for recruitment of specialists under Pk-13, 70 lac for spatial database consulting services, 85 lac for flood modeling in Bagmati Basin) and that would raise total commitment to Rs 4.5 crore approx.

fmis e-bulletin

Flood Management Improvement Support Centre
Water Resources Department
Bihar



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Contents

"Towards a culture of preparedness for better flood management"

From the Joint Director's Desk

Both the flood and festive seasons have passed almost smoothly. The monsoon has been good this year after two successive years of draught. According to the report of IMD, the total rainfall from 1st June to 15th October 2011 has been 1060 mm which is only 1.45% less than normal rainfall. This has definitely given a sigh of relief in the agriculture sector. We may hope good *kharif* as well as *rabi* crops this year.

This months FMISC bubbled with many activities. On 16th October, there was one day seminar to demonstrate the use of satellite imageries to have an idea of the proximity of the rivers and the vulnerability of the sites for proposed anti-erosion works for Chief Engineers of different zones of WRD as it was done last month for Chairmen of different Flood Fighting Force working in the various flood zone of Bihar.

A *training workshop* titled ***'International Approaches to Manage and Plan Embankment Assets'*** was organized by FMISC under technical assistance from World Bank during 17-20 October at Patna. The trainers were Mr. Alan Tamm and Dr. Padmakar Srivastava from US Army Corps of Engineers. They shared their experiences and detailed the procedures and techniques being adopted for embankment management in USA. To get a first hand experience, experts from US Army Corps of Engineers and World Bank officials along with FMISC officers visited some of the embankments in Bagmati-Adhwara basin on 15-16 October. Mr. Tamm demonstrated the use of PC Tablets for regular monitoring of embankment maintenance and emphasized the need of checklist for regular embankment inspection. The training workshop was attended by field engineers of Bagmati-Adhwara basin, FMISC officers and specialists and Chairmen of different Flood Fighting Force.

Another World Bank ***Identification Mission*** team visited Patna for ***Proposed Bihar Flood Recovery Program Phase II*** from October 17 to October 21. The mission objective was to identify the activities to be financed, explore implementation arrangements and start the preparation of safeguard documentation in order to build momentum and gain project approval at the earliest.

We are on way to accomplish our missions in hand successfully……

Editorial

Monsoon 2011 came to end with normal rainfall this year. Over all the flood event occurred this monsoon due to intense, short duration rainfall in the river basin. The intense rainfall in Jharkhand and West Bengal resulted in flooding of Ganga causing a traffic jam of water in Bihar region which resulted in a high water level of Ganga for considerable period of time resulting in flood episode. Excessive rainfall in upper catchments of river Sone in Madhya Pradesh and Utter Pradesh resulted in very heavy discharge at Indrapuri Barrage. In the lower region pressure was built up at Sahar in Bhojpur district and at around Arwal. Also few pockets of flood inundation occurred in Gangetic flood plan in Buxar and Bhojpur district due to excessive rainfall in adjoining area of Uttar Pradesh. FMIS produced a large number of event & area specific maps for TAC for deciding anti erosion schemes to be executed during year 2012. FMIS also conducted a presentation to appraise Chairman of Flood Fighting Force (FFF) and Chief Engineer of flood affected area with application of Remote Sensing & GIS technique application in flood management. This was appreciated by one and all.

Embankment Asset Management System : A brief note

In FMIS phase –II project, a major component is to design and develop an Embankment Asset Management System (EAMS) for the pilot Bagmati-Adhwara basin. The general functionalities of the EAMS are expected to include:- 1)Data Viewer to display (graphically and numerically) and generate summary statistics on various user-selected databases, 2)Generate dynamic spatial maps of various hydraulic data, engineering data (geo-referenced) and field reports. This may include color-coded markers reflecting critical embankment management parameters (e.g. time of last maintenance, current water levels, etc.), 3)Ability to upload and download various datasets, 4)Generate specialized alerts and notifications to distribute (via e-mail or SMS) to various WRD and DMD officers, 5)Ability to generate specialized summary reports on pre-selected topics (e.g. water level conditions, flood reports, etc), 6)Analytical module on maintenance scheduling, prioritization and monitoring of existing embankments, 7)Analytical module for planning new flood protection works.

News in Picture

Mr. Alan Tamm, Expert from USACE, delivering use of PC Tablet for better embankment inspection

Mr. Afzal Amanullah, Principal Secretary, WRD, GoB with USACE experts and WB officials in the concluding session of the EAMS workshop →

Visit of USACE Experts:

To supplement the EAMS objective, a four days workshop on 'International Approaches to Manage and Plan Embankment Assets' was organized from 17-10-2011 to 20-10-2011 by the World Bank at Patna. The workshop was attended by engineers from the department both from field and headquarter along with some field Chief Engineers and Chairmen of Flood Fighting Force. The trainers were experts from **United States Army Corps of Engineers** (USACE) who imparted the use of latest technology e.g. use of tablet PC with GPS and shared their international experiences in the field of Embankment inspection. The workshop was inaugurated by Dr. Winston Yu, Task Team Leader, World Bank, along with Mr. Alan Tamm and Dr. Padmakar Srivastva, experts from USACE. The workshop formally ended on 19-10-2011. Mr. Afzal Amanullah, Principal Secretary, WRD, Bihar addressed the formal concluding session and expressed his happiness for organizing such workshop. The workshop ended with vote of thanks by Er. A.K. Samaiyar, Joint Director, FMISC. The participants met on 20th October 2011 to discuss and formulate inspection checklist of Embankment specially designed for Bihar. Earlier, a two days field visit and inspection of Embankments under Bagmati-Adhwara basin was undertaken by World Bank officials along with experts from USACE during 15-16 October 2011 also.

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