FLOOD STUDIES AND PERFORMANCE EVALUATION OF THE FLOOD MANAGEMENT SCHEMES

- ➢ DESIGN FLOOD ESTIMATION
- ➢MORPHOLOGICAL STUDIES
- ➢FLOOD HAZARD MAPPING AND FLOOD RISK ZONING
- ➢PERFORMANCE EVALUATION

DESIGN FLOOD ESTIMATION

Objectives

To screen the available data, using the L-moment based discordancy measure (Di) test.

➢To test the regional homogeneity using the L-moment based "Heterogeneity measure, (H)" test.

➢To carryout comparative regional flood frequency analysis studies employing various frequency distributions using L-moments approach.

➢To identify robust regional frequency distribution based on L-moment ratio diagram and Zdist statistic criteria.

➢To develop regional flood frequency relationship for estimation of floods for different return periods for the gauged catchments of the study area.

Objectives (Contd.)

- To develop regional flood frequency relationship for estimation of floods for different return periods for the gauged catchments of the study area.

- To develop regional relationship between mean annual peak floods and physiographic characteristics for estimating the mean annual peak flood for the ungauged catchments of the study area.

- To couple the regional relationship between mean annual peak flood and physiographic characteristics with the regional flood frequency relationship for developing the regional flood formula for estimation of floods of various return periods for ungauged catchments of Subzone 1(f).

CASE STUDY FOR DESIGN FLOOD ESTIMATION:
The Study Area

The Middle Ganga Plains Subzone 1(f) of India lies between latitudes 24° to 29° North and longitudes 80° to 89° East.

The total areal extent of the Subzone 1(f) is 1, 71, 350 km^2.

The major rivers flowing in this Subzone are Ganga, Yamuna, Gomti, Gandak, Ghagra, Rapti, Kosi including Kamla, and Mahananda.

The mean annual rainfall in this Subzone varies from 800 mm to 1200 mm in the plains and goes upto 2000 mm

Annual maximum peak flood data of 11 gauging sites lying in the Subzone 1 (f) and varying over 11 to 33 years in record length, are available for the study.

Catchment areas of these sites vary from 27.45 to 712 km^2. Mean annual peak floods of these sites vary from 24.29 to 555.21 m^3/s.

Data Screening and Regional Homogeneity Test

The data were screened using the L-moments based Discordancy measure (Di) test.

Homogeneity of the region has been tested using the L-moment based heterogeneity measure, H by carrying 500 simulations using the four parameter Kappa distribution.

Based on the homogeneity test, it has been observed that the data of 8 out of 11 sites constitute a homogeneous region. Hence, the data of these eight sites have been used in this study.

Parameter Estimation Techniques

Method of least squares

Method of moments

Method of maximum likelihood

Method of probability weighted moments

Method based on principle of maximum entropy

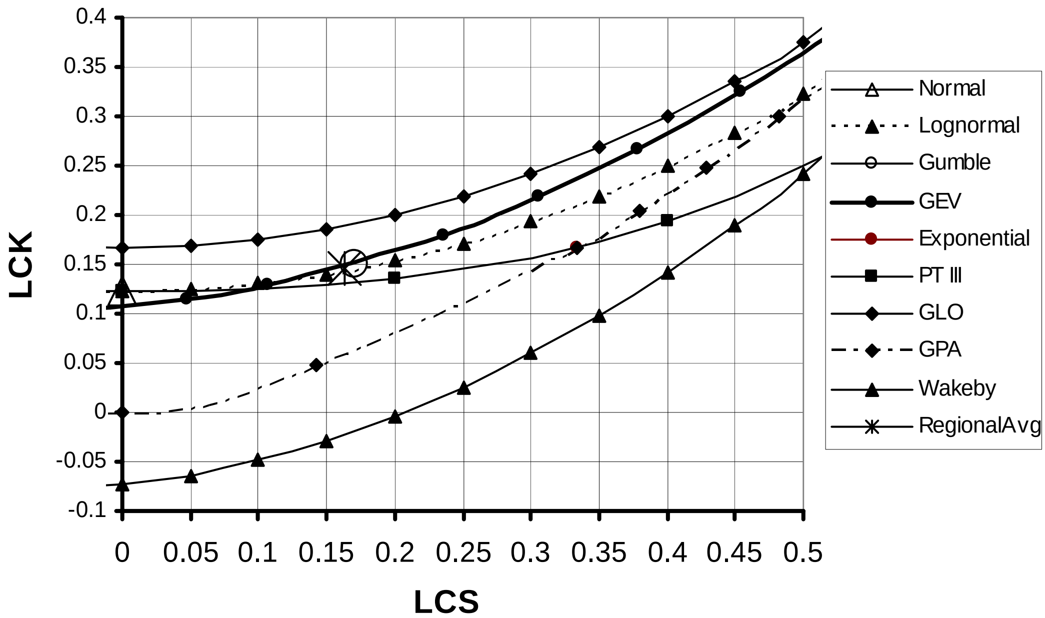
Method based on L-moments

Identification of Regional Frequency Distribution Based on

The L-moment ratio diagram approximations, and

The L-moment based Zdist–statistic criteria.

As shown in figure (next slide), the GEV distribution lies closest to the point defined by the regional average values of L-skewness and the same is identified as the regional distribution, as per this criteria.



L-moment ratio diagram for Subzone 1(f)

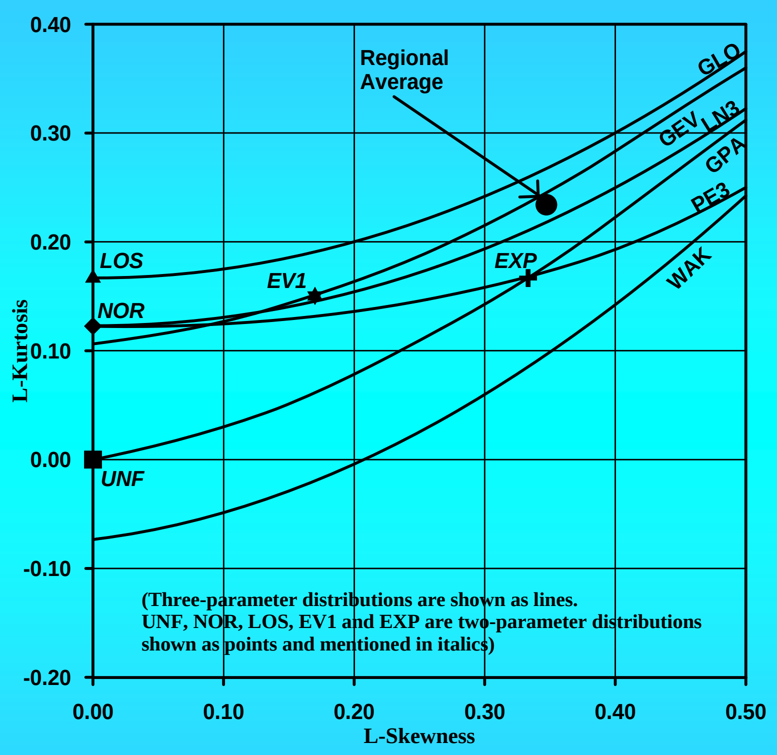


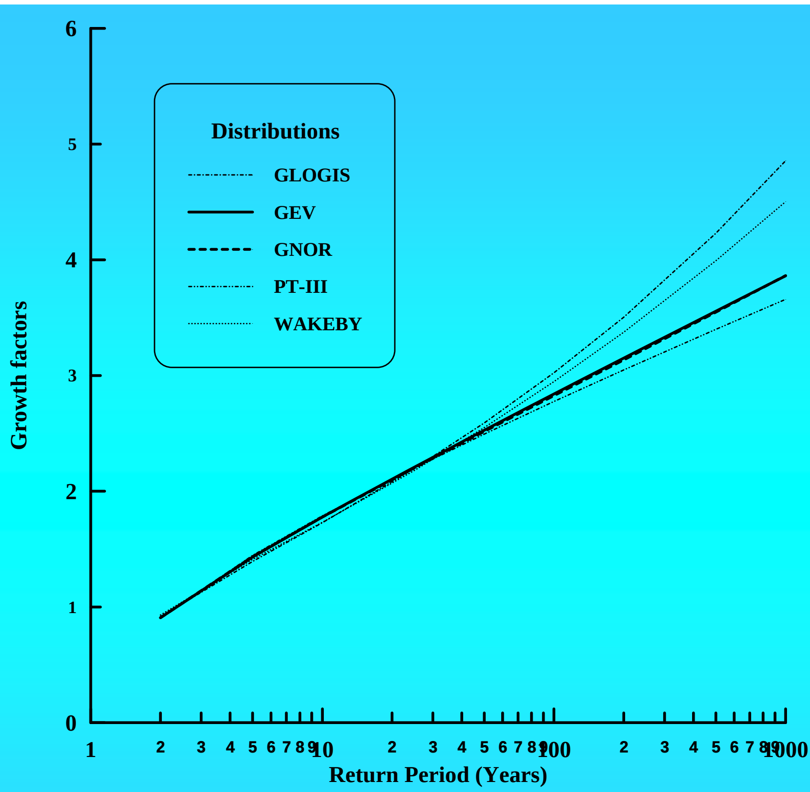
Figure 1. L-moment ratio diagram for Sone Subzone 1(d).

Z^{dist} Statistic for various distributions

S. No.	Distribution	Z-Statistic
1	GEV	0.01
2	GNO	-0.14
3	PT-III	-0.62
4	GLO	1.58
5	GPA	3.40

It is observed that the Zdist –statistic value is lower than 1.64 for the four distributions viz. GEV, GNO, PT-III and GLO.
Further the Zdist –statistic is found to be the lowest for GEV distribution i.e 0.01; which is very close to 0.0.

Thus, the L-moment ratio diagram as well as Zdist –statistic criteria ascertain that the GEV distribution is the robust distribution for Subzone 1(f).



Variation of growth factors obtained by GEV GNOR, PT-III, GLO and WAK for various return period for subzone 1 (f)

Developed Regional Flood Formula for Ungauged Catchments

The developed regional flood formula for ungauged catchments of Subzone 1 (f) is expressed as:

$$Q_T = \left[34.842 - 34.304 \left\{ -\ln\left(1 - \frac{1}{T}\right)\right\}^{0.01} \right] A^{1.084}$$

Here, QT is flood estimate in m^3/s for T year return period, and A is catchment area in km^2.

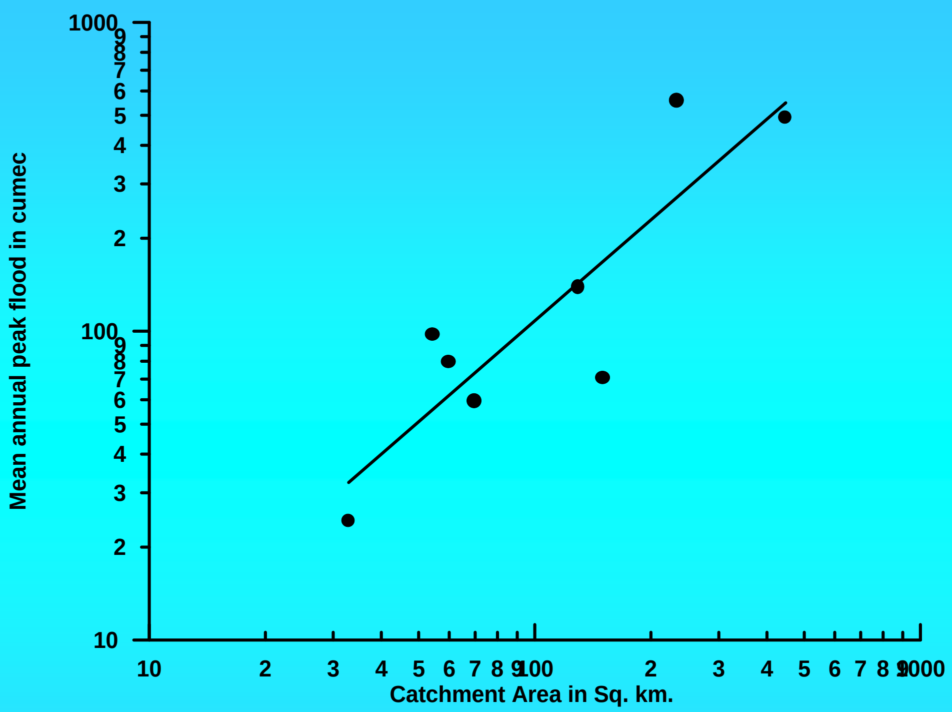
Development of Regional Relationship between Mean Annual Peak Flood and Catchment Area

The regional relationship between (m^3/sec) and A (km^2) developed for the region in log domain using least squares approach is given below.

$$\overline{Q} = 0.733\,(A)^{1.084}$$

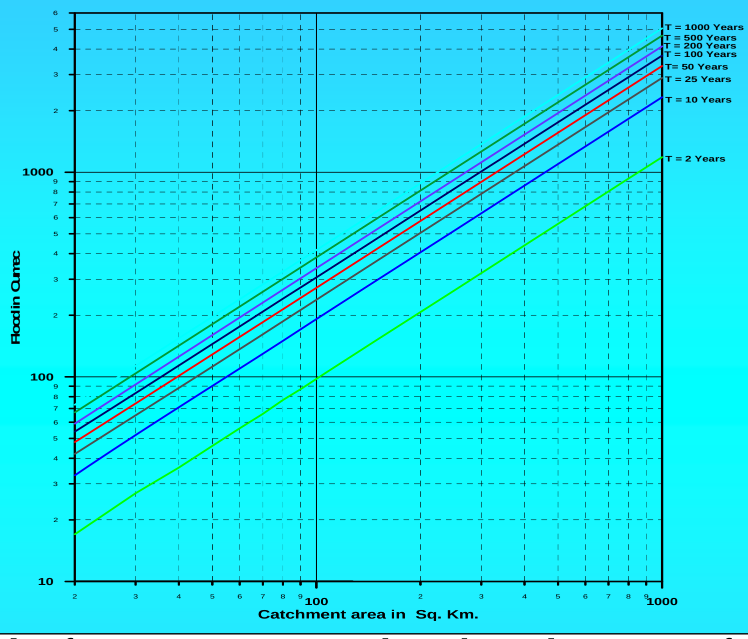
for this relationship the correlation coefficient is, r = 0.879, Coefficient of determination, r2 = 0.774 and the standard error of the estimates is obtained as 0.545.

Variation of mean annual peak floods with catchment area for the 8 gauging sites of the study area is shown below.



Variation of mean annual peak flood with catchment Area for Subzone 1(f)

Graphical representation of the developed regional flood formula is illustrated below



Variation of floods of various return periods with catchment area for Sub zone 1(f)

The values of floods of various return periods (QT) computed using the developed regional flood formula for different catchment areas are given below in Tabular form.

Catch. Area (km²)	Return periods (Years)								
	2	5	10	25	50	100	200	500	1000
	Floods of various return periods (m³/s)								
20	17	27	33	42	48	54	59	67	73
30	27	42	52	65	74	83	92	104	113
40	36	57	71	88	101	114	126	142	154
50	46	73	90	112	129	145	160	181	197
60	56	89	110	137	157	176	195	221	240
70	66	105	130	162	185	208	231	261	283
80	77	121	150	187	214	241	267	301	327
90	87	138	171	213	243	273	303	342	372
100	98	154	192	238	273	306	340	384	417
150	152	240	297	370	423	476	528	596	647
200	207	327	406	505	578	650	721	814	884
250	264	417	518	644	736	828	918	1036	1125
300	322	508	631	784	897	1008	1119	1263	1371
350	380	601	745	927	1060	1192	1322	1493	1621
400	439	694	861	1071	1226	1377	1528	1725	1873
450	499	789	979	1217	1392	1565	1736	1960	2128
500	560	884	1097	1365	1561	1754	1946	2197	2386
550	621	980	1216	1513	1731	1945	2158	2436	2645
600	682	1077	1337	1663	1902	2138	2372	2677	2907
650	744	1175	1458	1813	2074	2331	2587	2920	3170
700	806	1273	1580	1965	2248	2526	2803	3164	3436
750	869	1372	1703	2118	2423	2723	3021	3410	3702
800	931	1471	1826	2271	2598	2920	3240	3657	3971
850	995	1571	1950	2425	2775	3118	3460	3906	4240
900	1058	1672	2075	2580	2952	3318	3681	4155	4511
950	1122	1773	2200	2736	3130	3518	3903	4406	4784
1000	1186	1874	2326	2893	3309	3719	4126	4658	5057

CONCLUSIONS

✓For estimation of floods of various return periods for the gauged catchments of the study area, either the developed regional flood frequency relationship may be used or the mean annual peak flood of the catchment may be multiplied by the corresponding values of the growth factors.

✓The developed regional flood formula, its graphical representation or its tabular form may be used for estimation of floods of desired return periods for the ungauged catchments of the study area.

✓As the regional flood formula has been developed using the data of catchments ranging from 32.9 km^2 to 447.8 km^2 in area; therefore, the developed regional flood frequency relationship or flood formula may be expected to provide estimates of floods of various return periods for the catchments of Subzone 1(f), lying nearly in the same range of areal extent, as those of input data.

CONCLUSIONS (contd.)

✓The data of only 8 gauging sites, varying from 23 to 33 years have been used in this study. The relationship between mean annual peak flood and catchment area developed on the basis of available data is able to explain 77.4% of initial variance (r2 = 0.774) and the standard error of the estimates is obtained as 0.545. Hence, the results of the study are subject to these limitations.

✓The developed regional flood formulae may be further refined when the annual maximum peak flood data for some more gauging sites become available and catchment and physiographic characteristics other than catchment area are also used for development of the regional flood formula.

MORPHOLOGICAL STUDIES USING REMOTE SENSING

OBJECTIVES

To study the shifting course of river Ghaghra from 1974-76(SOI toposheet) to 1990 (Digital data of IRS-1A LISS-II data); from 1990 to 1994 (digital data of IRS-1B LISS-II); and from 1994 to 1999 (digital data of IRS-1C LISS-III) and from 1999 to 2003 (digital data of IRS-1D LISS-III)

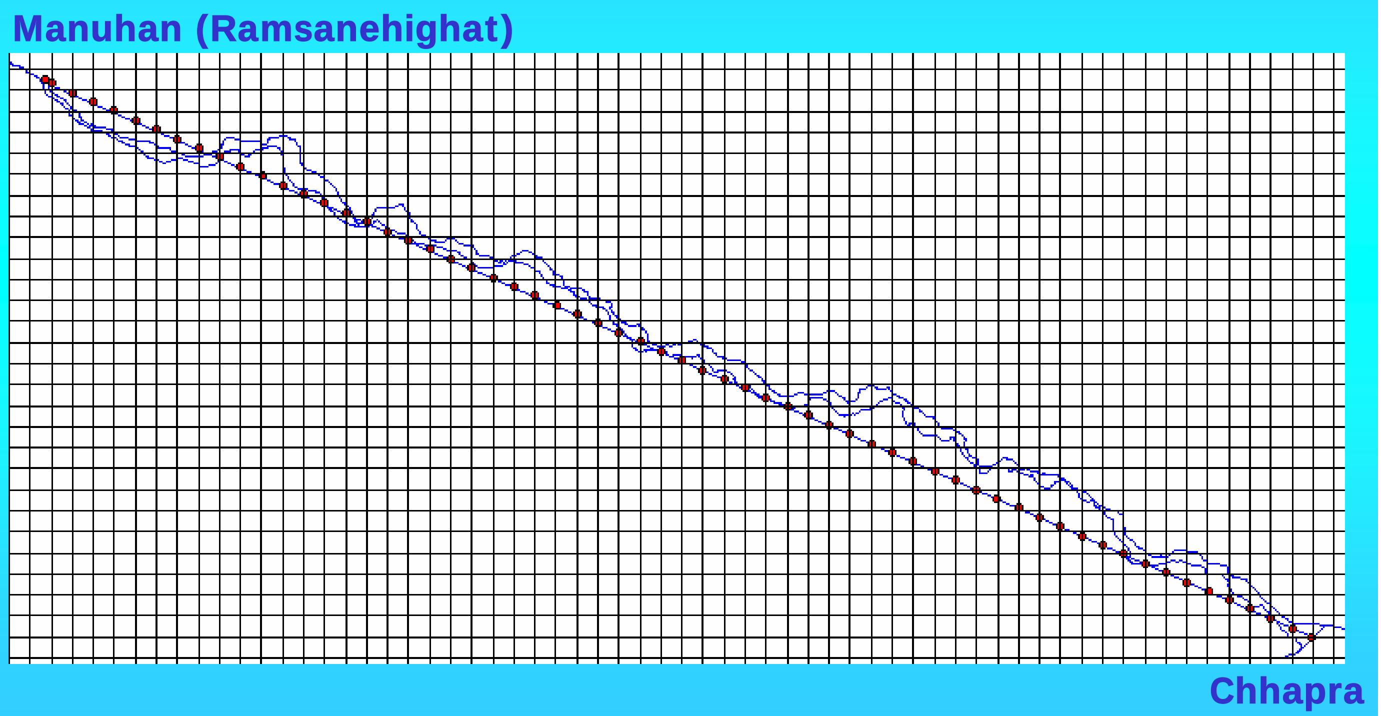
To identify the critical locations along the river where major shifting has taken place.

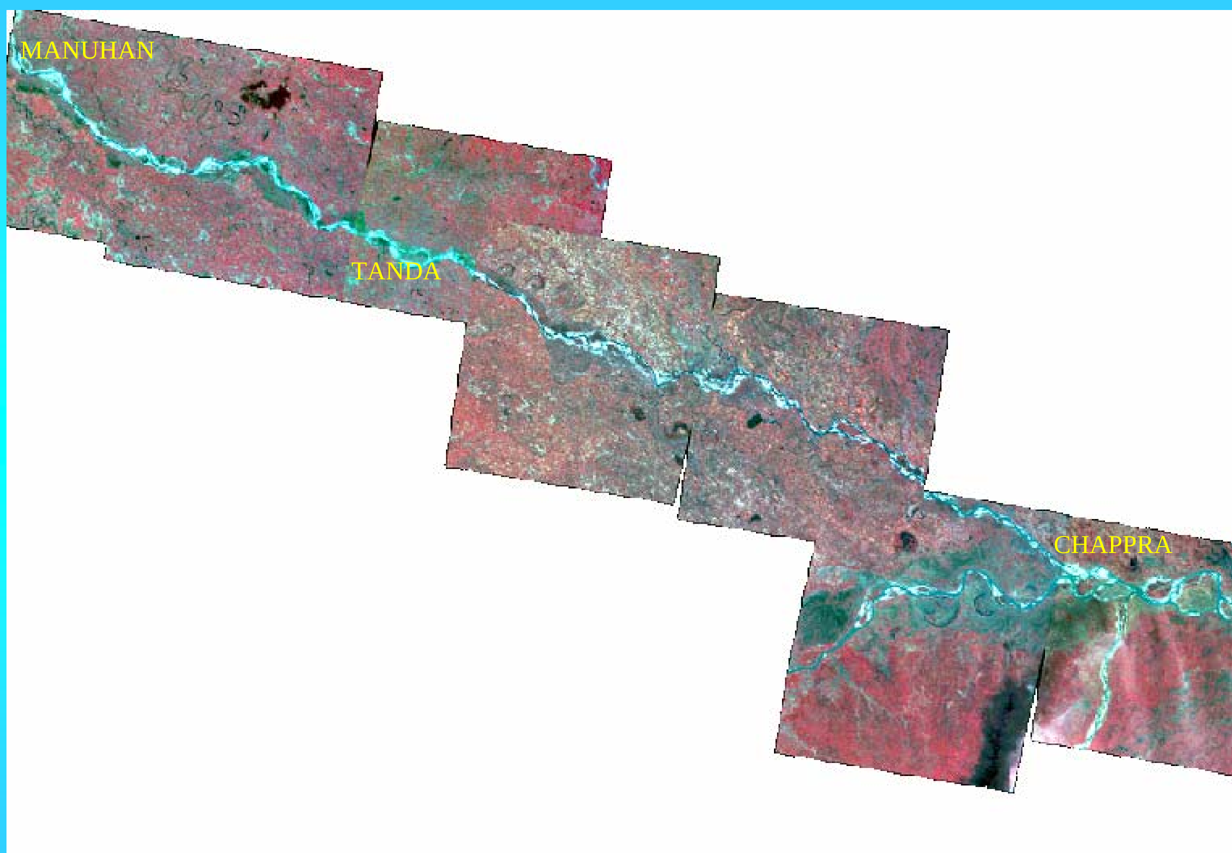
METHODOLOGY

1. Base Layer generation using Survey of India toposheets
2. Delineation of river course
3. Analysis of Digital data of IRS LISSII and LISSIII
4. Georeferencing, Separation of AOI and river course delineation
5. Evaluation of shifting of course of rivers from SOI to satellite data of different years
6. Identification of critical locations from shifting point of view.

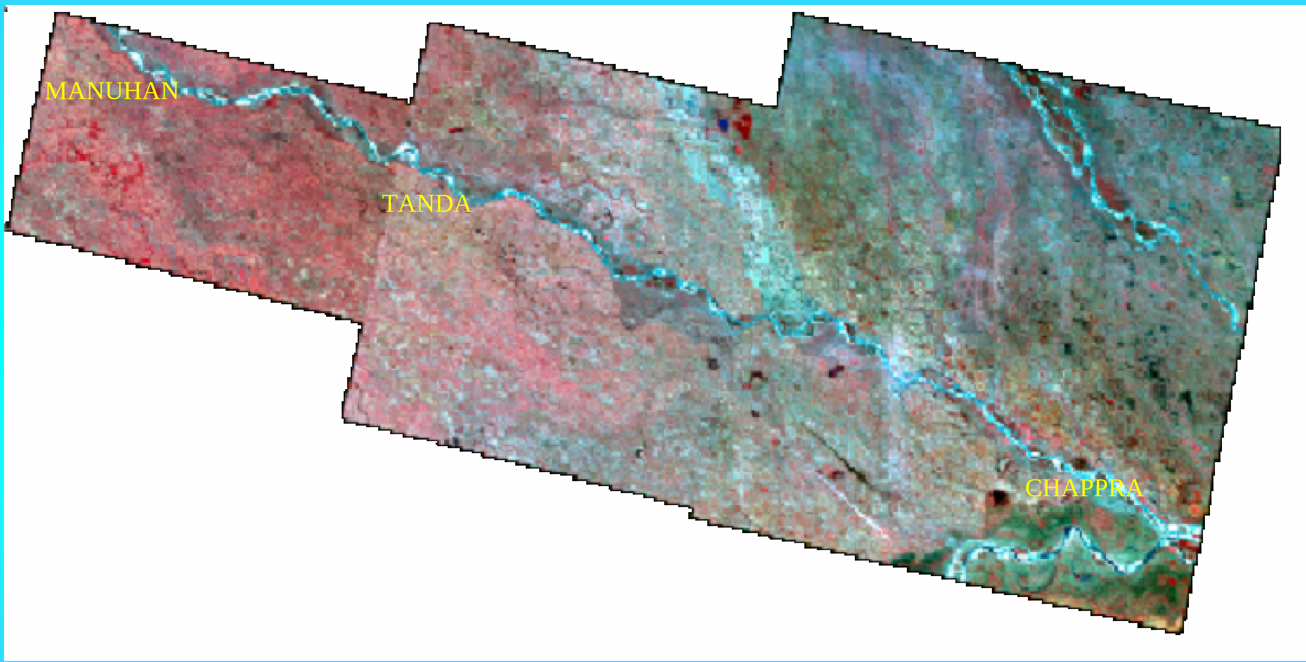
River reach of Ghagara River with offsets at regular interval

Length 373 kms

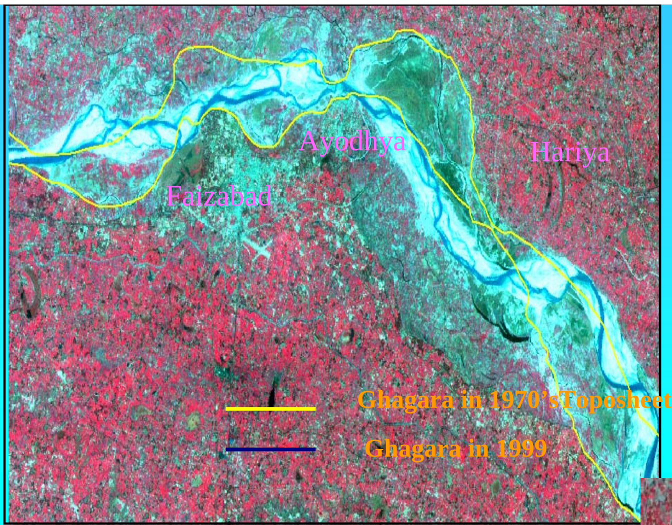




MOSAIC of FCC of Ghagara River of 1990

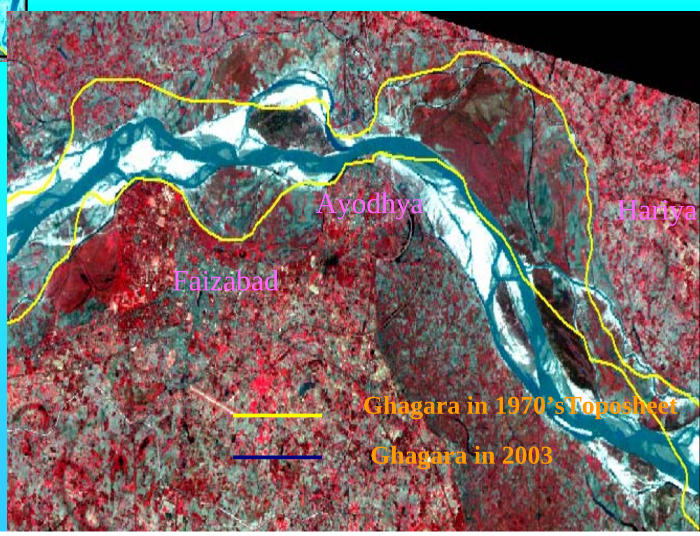


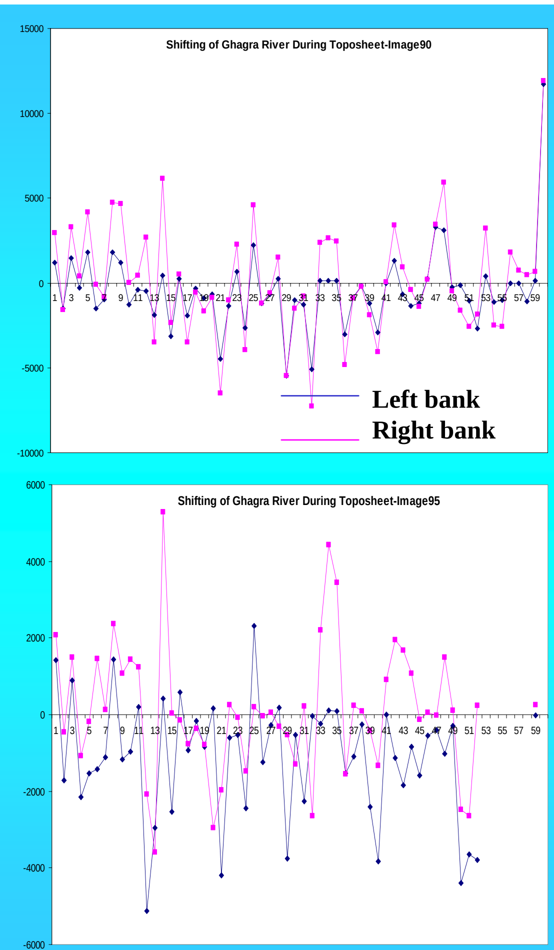
MOSAIC of FCC of Ghagara River of 2003



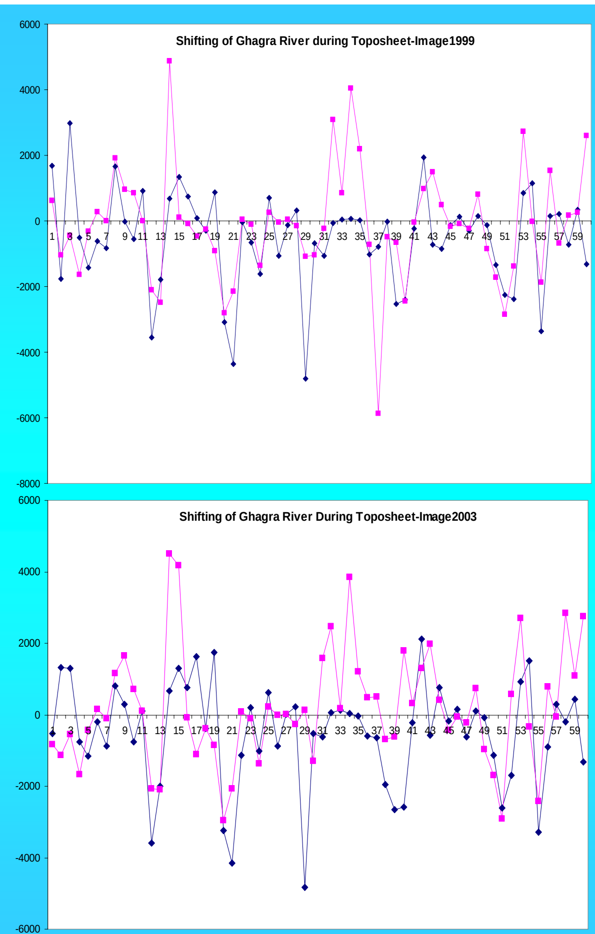
False Colour Composite (1999) overlaid by drainage from toposheet (Ghagara)

False Colour Composite (2003) overlaid by drainage from toposheet (Ghagara)

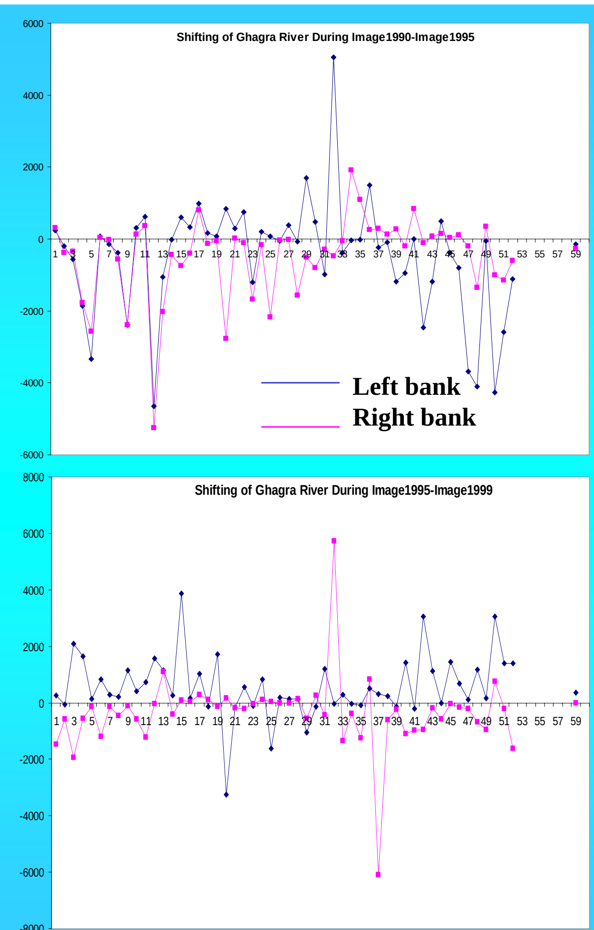




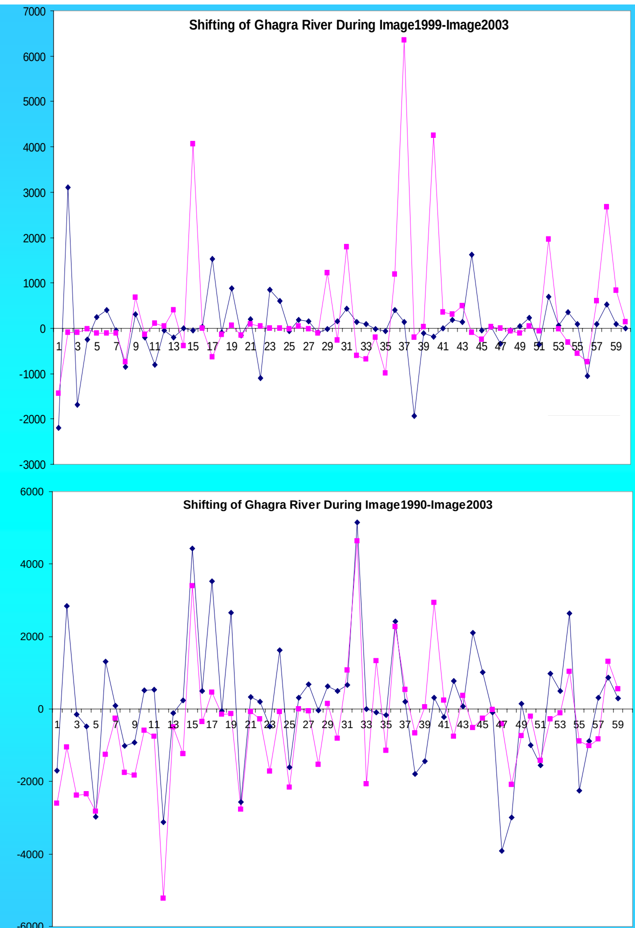
Shifting of Ghagara River from toposheet to LISSII data



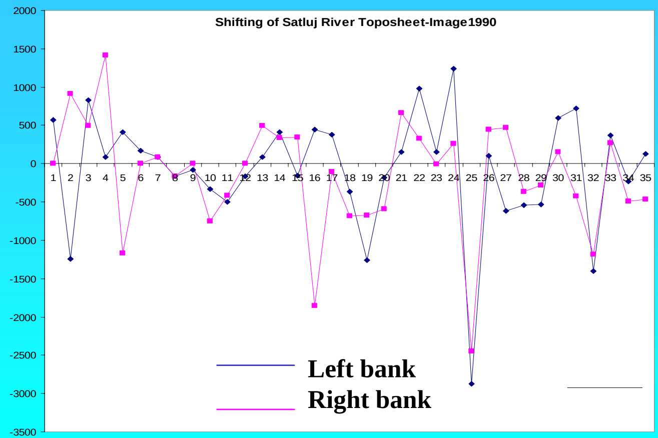
Shifting of Ghagara River from toposheet to LISSIII data

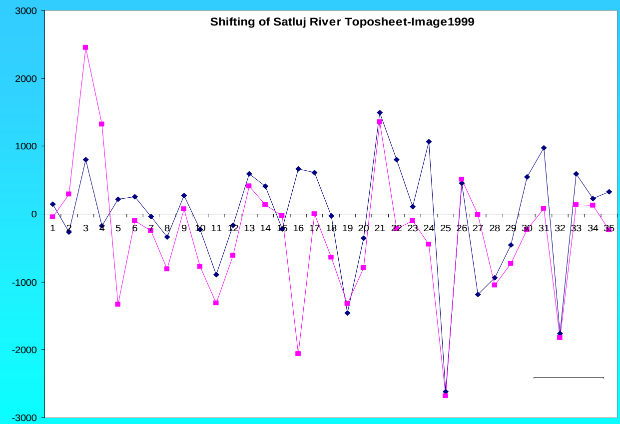


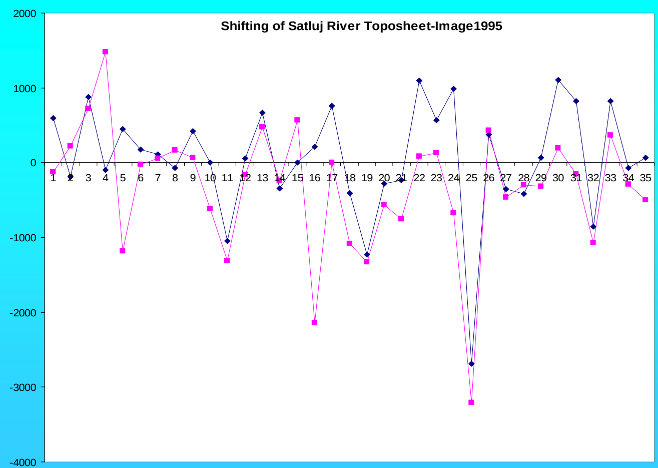
Shifting of Ghagara River from Image of LISSII and LISSIII data

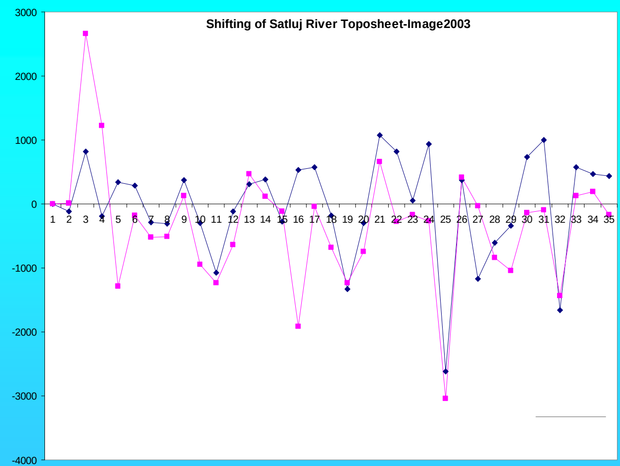


Shifting of Ghagara River from Image of LISSII to LISSIII data



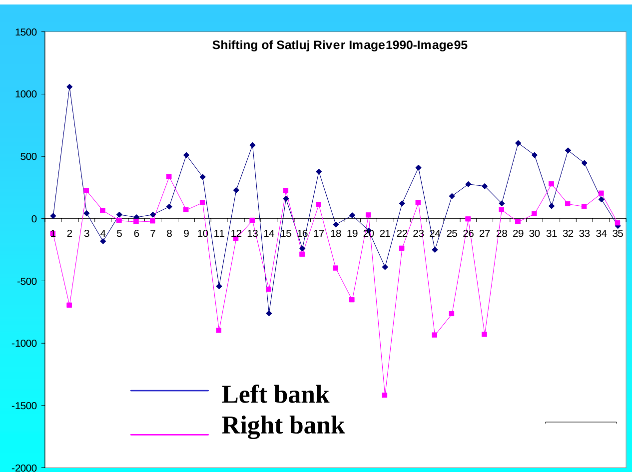


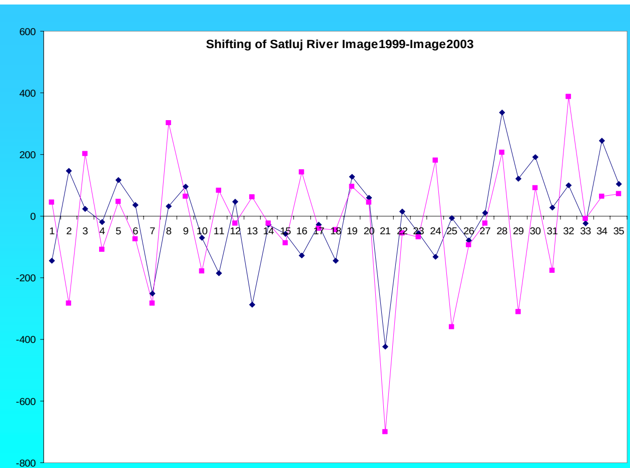


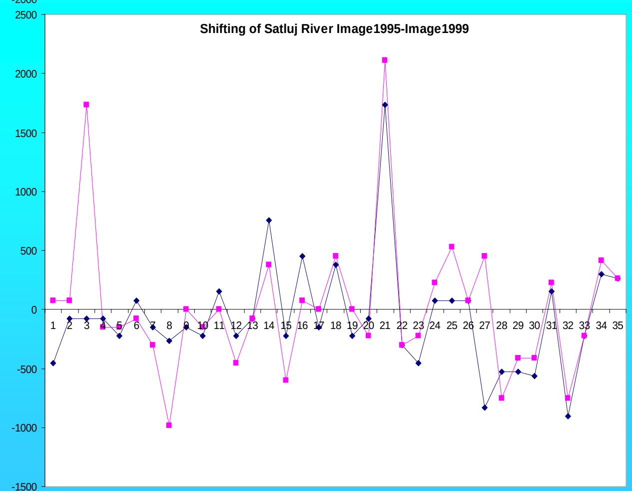


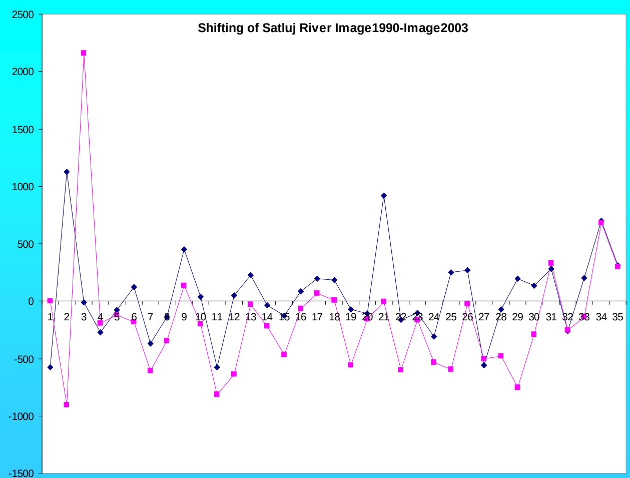
Shifting of Satluj River from toposheet to LISSII data

Shifting of Satluj River from toposheet to LISSII data









Shifting of Satluj River from Image of LISSII to LISSIII data

Shifting of Satluj River from Image of LISSII to LISSIII data

CONCLUSIONS

The shifting characteristics of reaches of the River Ghagara between Manuhan (Ramsnehighat) to Chhapra having a length of 370 km have been carried out.

The IRS data of four years 1990, 1995, 1999 and 2003 have been used.

The River Ghagara has been divided into ten reaches and reach wise analysis has been done. In reaches 1,2,5,8,9 and 10 the shifting was comparatively less And it was of the order of 2.75 km.

In the remaining reaches the maximum shifting was high and it was of the order of 4.5 to 6.3 km.

Based on the analysis critical locations along the River Ghagara are Tanda, Ayodhya, Golabazar, Barhaj and Bansdih.

Detailed study of the identified critical locations was carried out using IRS PAN data of the years 1999 and 2003.

Erosion and deposition occurred in different reaches.

To ascertain the reasons of the shift, field visits of some of the points were carried out.

On the basis of field visits and literature survey, it was observed that heavy mining of sand from its course and variation in flow are the reasons for shifting in River Ghagara.

Flood Hazard Mapping and Flood Risk Zoning for a River Reach

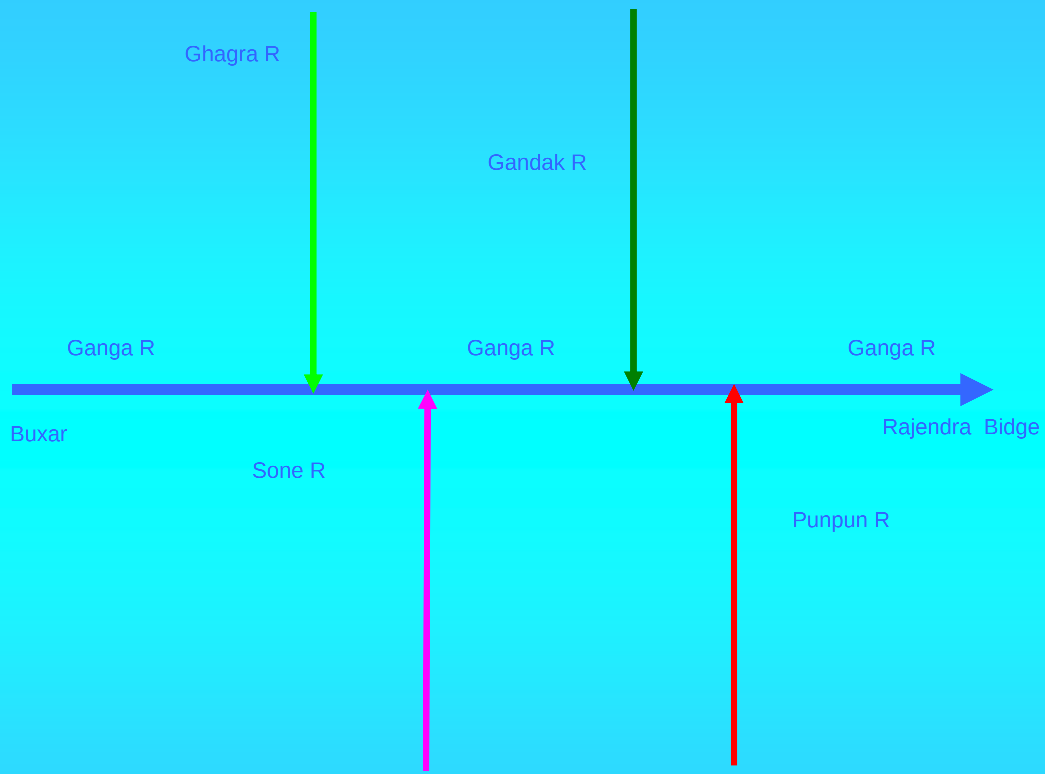
Objectives:

- To develop flood frequency relationships based on annual maximum peak flood series
- To develop rating curves for gauging sites of the river reach under study
- To prepare flood inundation and flood hazard maps for the river reach
- To prepare flood risk zone maps for the river reach.
- To predict flood inundation and flood hazard areas for various stages of river flow.

THE STUDY AREA

A RIVER REACH FOR GANGA BETWEEN BUXOR TO PATNA

BUXOR TO PATNA RIVER REACH LENGTH : 157.50 km



Schematic representation of the reach of the River Ganga between Buxar to Rajendra Bridge

The broad steps are:

- Estimation of floods of various return periods for the gauging sites of the river reach based on L-moments approach.
- Preparation of DEM of the study area using GIS.
- Computation of flooding for various return periods using HEC-GeoRAS 3.1& HEC-RAS 3.1.2 Packages.
- Development of flood inundation and flood hazard and flood risk zone maps for the study area relating the extent of flooding to its frequency as well as risk of occurrence of flooding.
- Evaluation of flooding patterns using satellite data.

HEC-RAS

Developed by

U.S. Army Corps of Engineers, Hydrologic Engineering Centre

HEC-RAS is an integrated system of software, designed for interactive use in a multi-tasking environment. The system is comprised of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities.

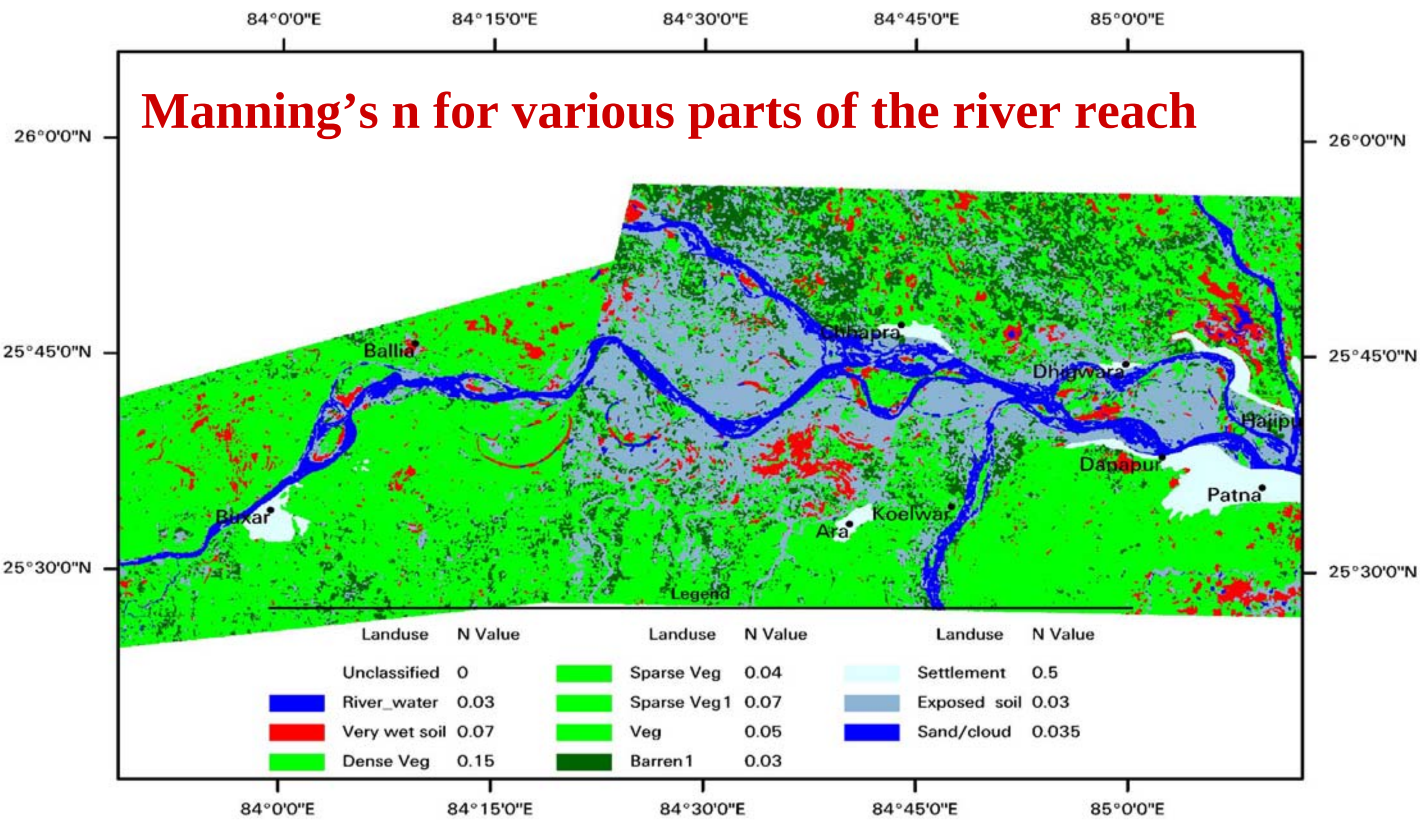
Programme Capability

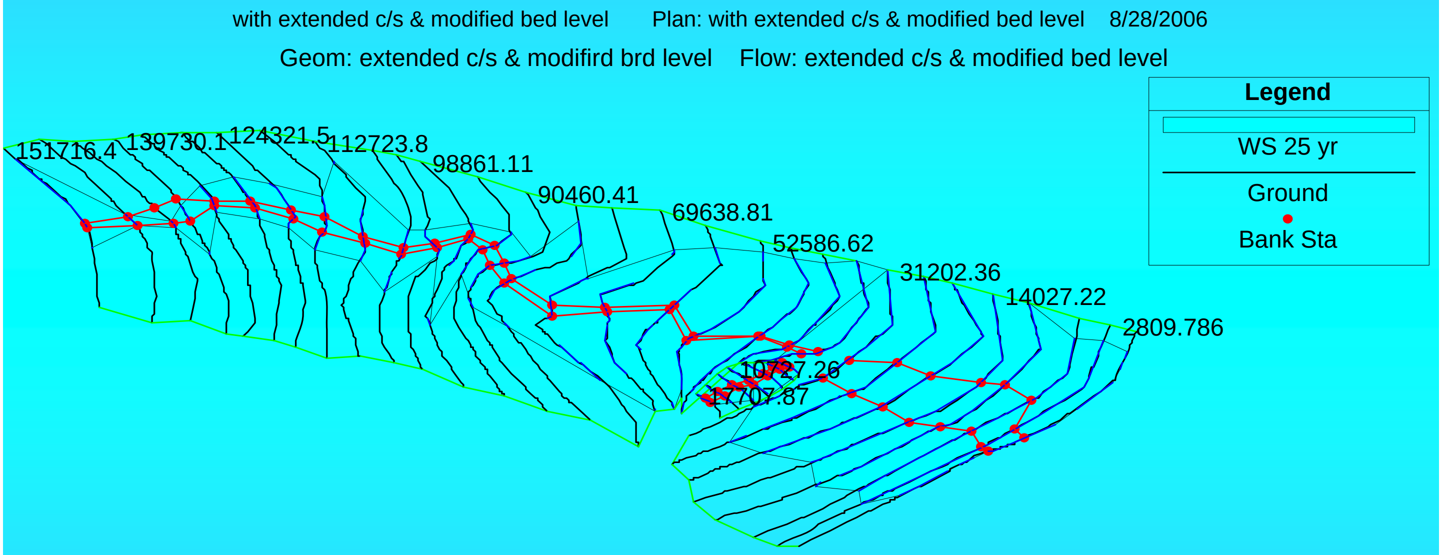
- Steady Flow Water Surface Profiles
- Unsteady Flow Simulation

Results

GEV, GLO and GPA distributions have been identified as the robust distributions for Gandhighat, Buxor and Koelwar sites, respectively.

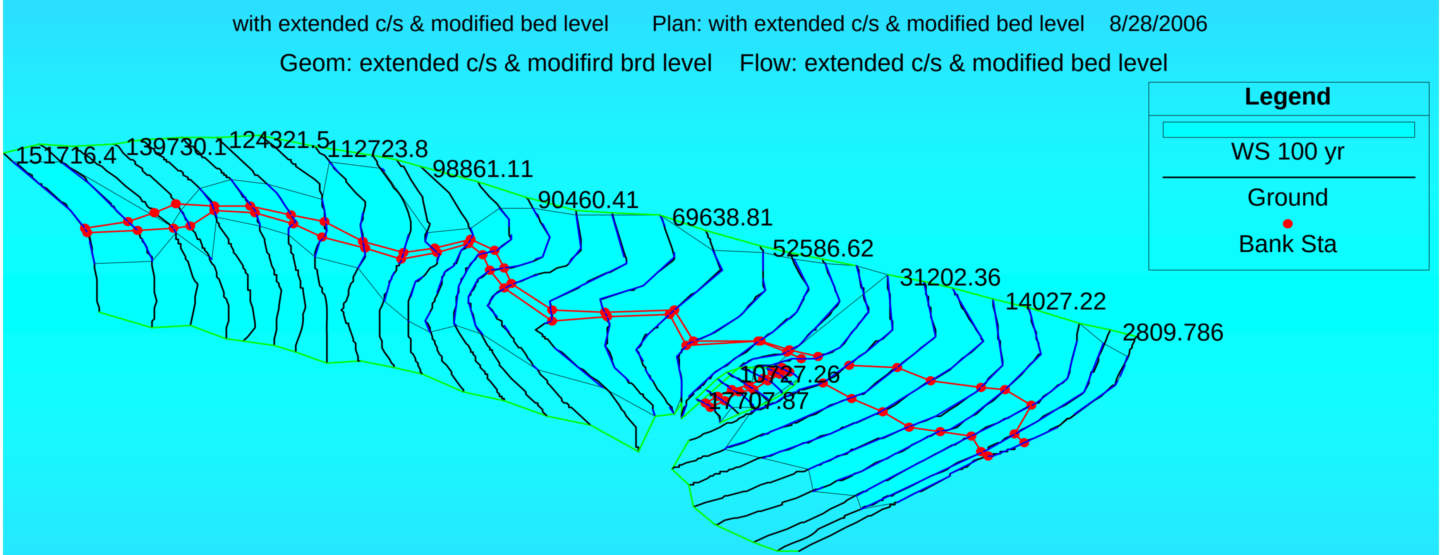
Using the respective robust frequency distributions, floods of various return periods viz. 2, 10, 20, 25, 50, 100, 200, 500 and 1000 years have been estimated for the two gauging sites.





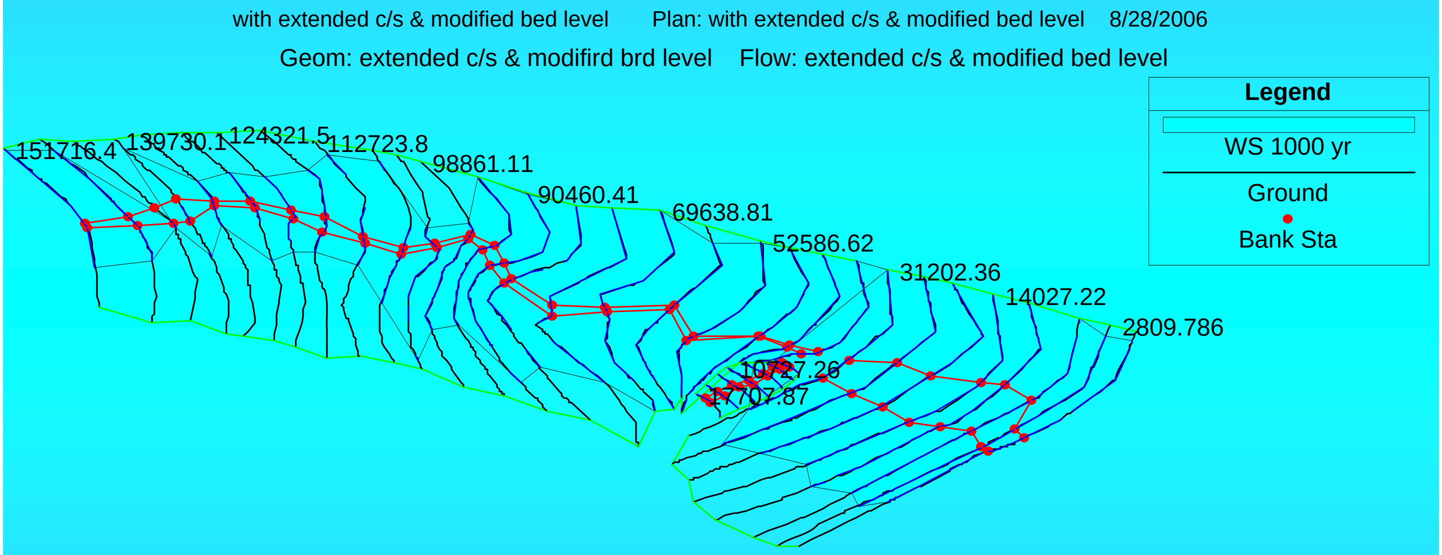
The extent of routed flood at various cross sections

For Return Period (T) = 25 years

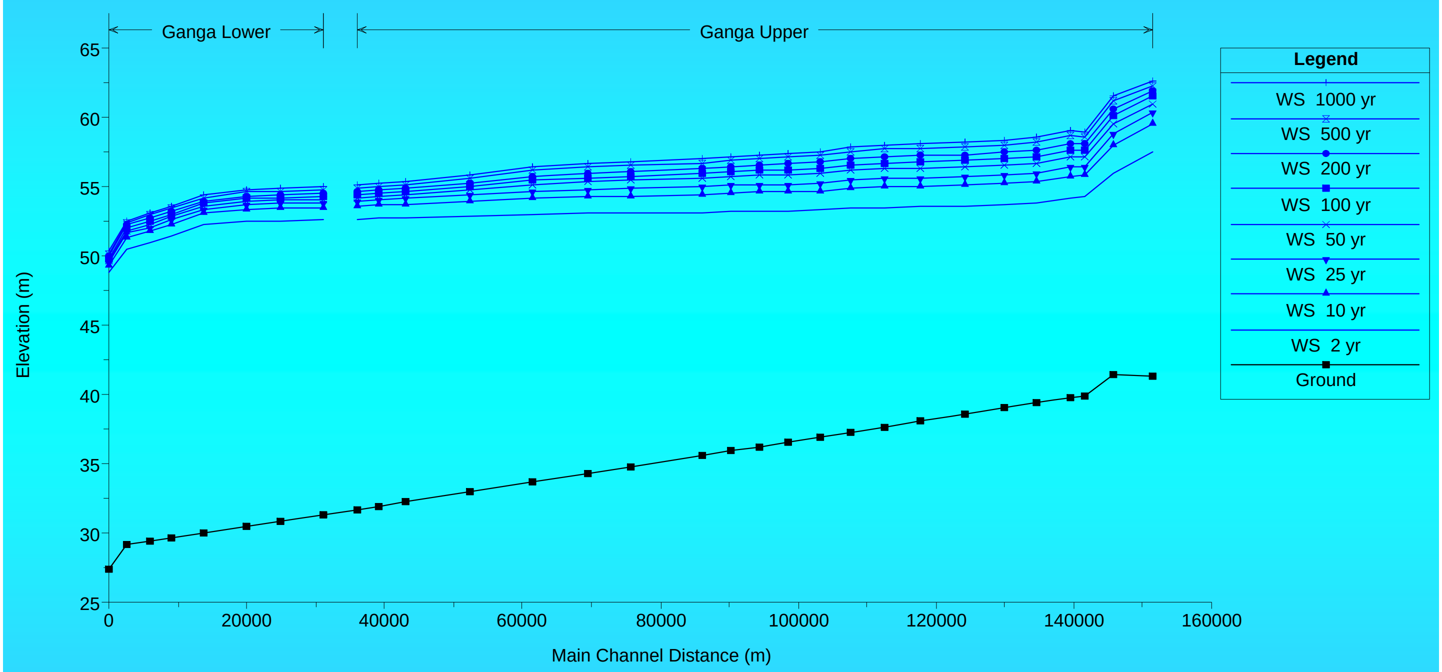


The extent of routed flood at various cross sections

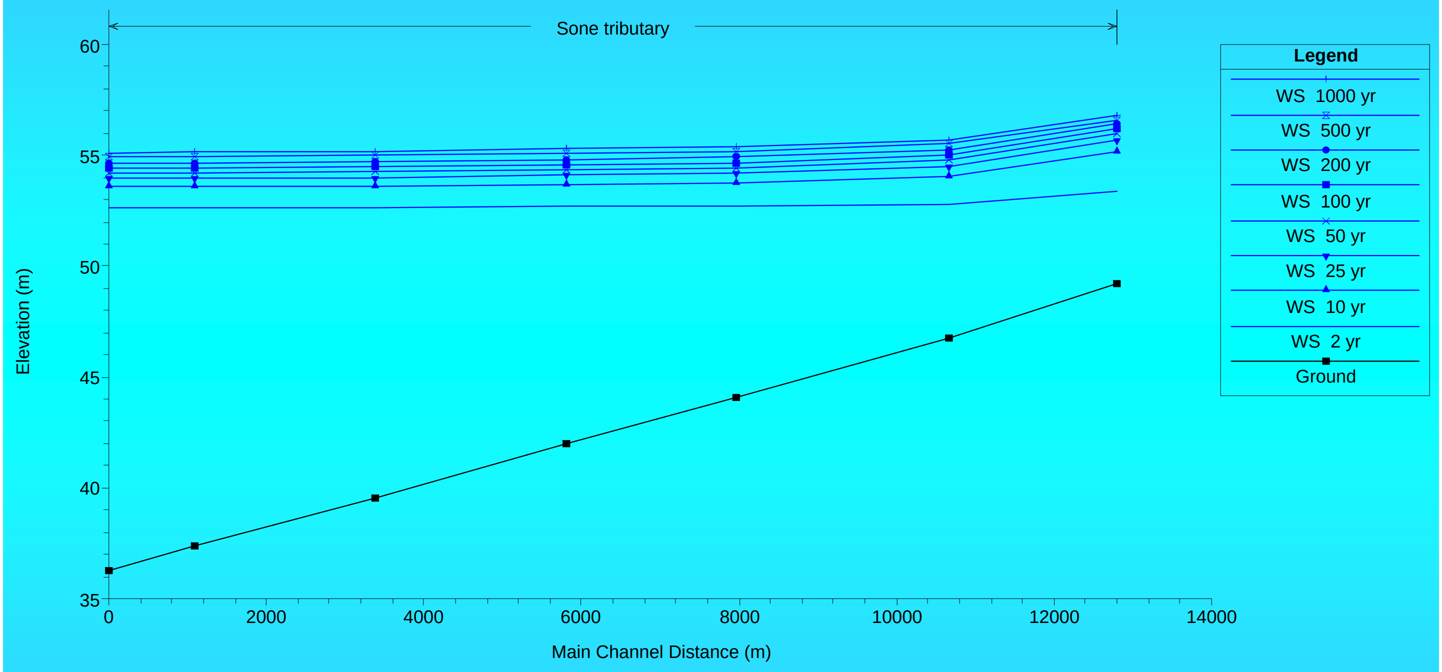
For Return Period (T) = 100 years



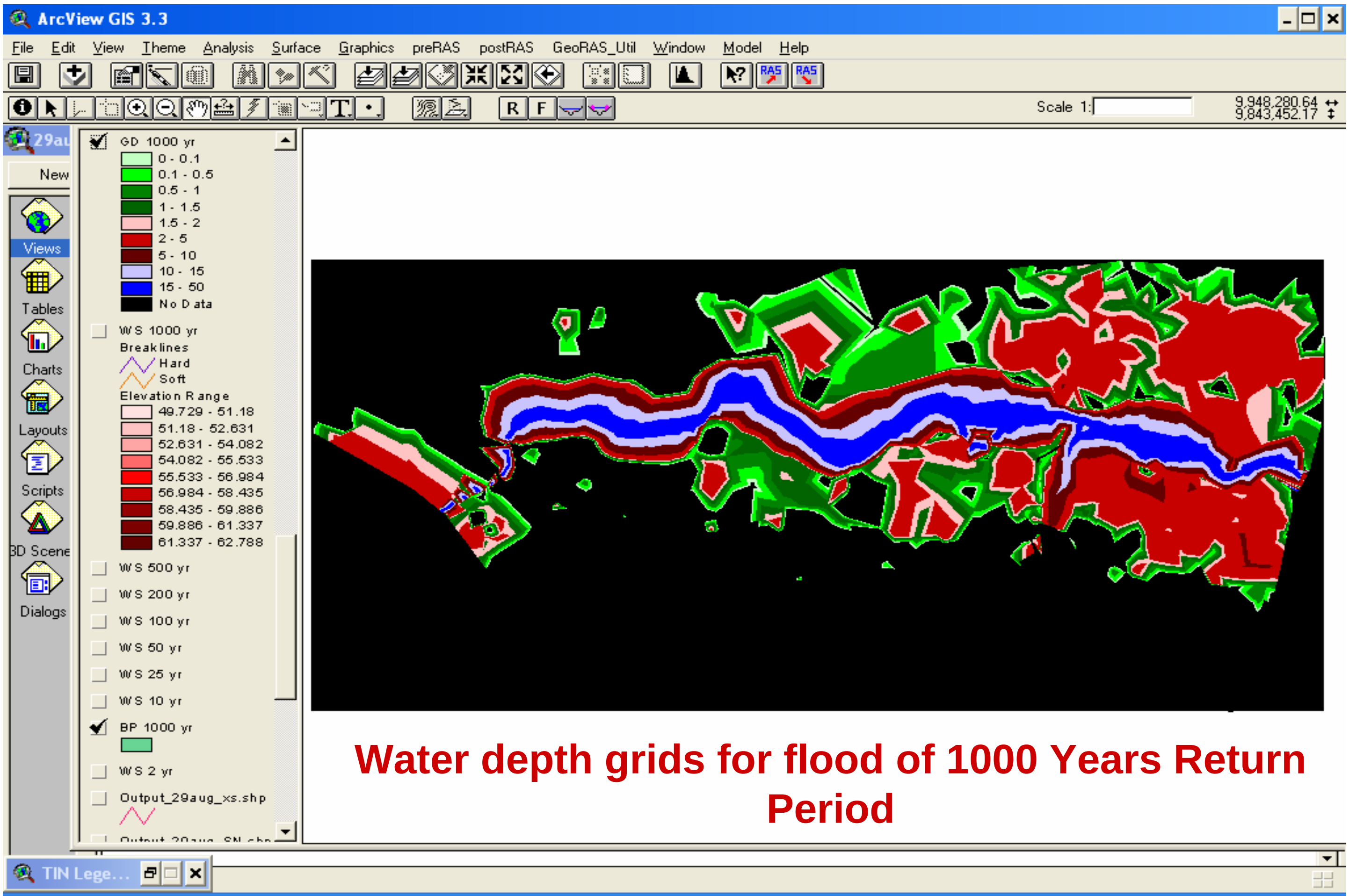
The extent of routed flood at various cross sections For Return Period (T) = 1000 years



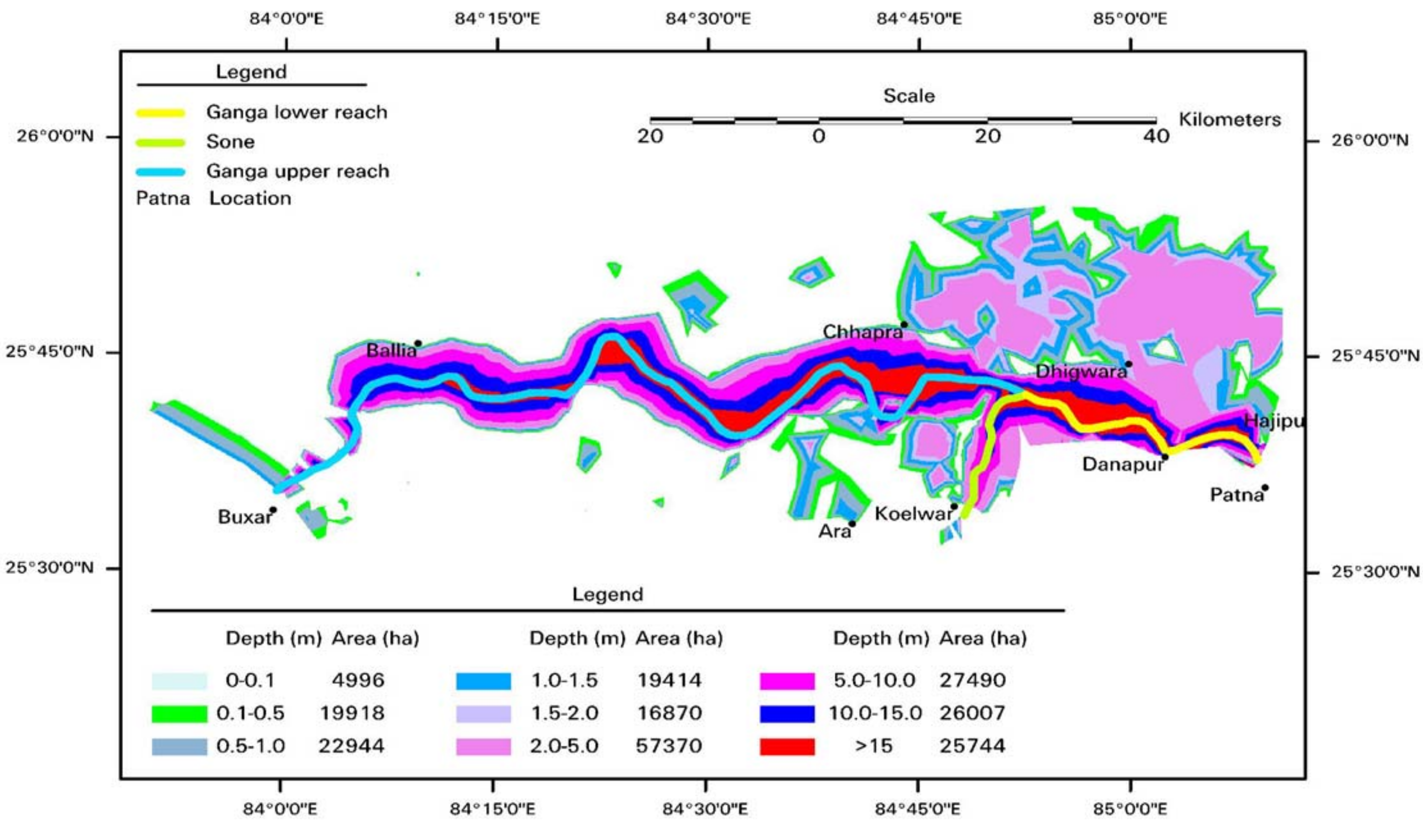
Water surface profile along the river for Ganga



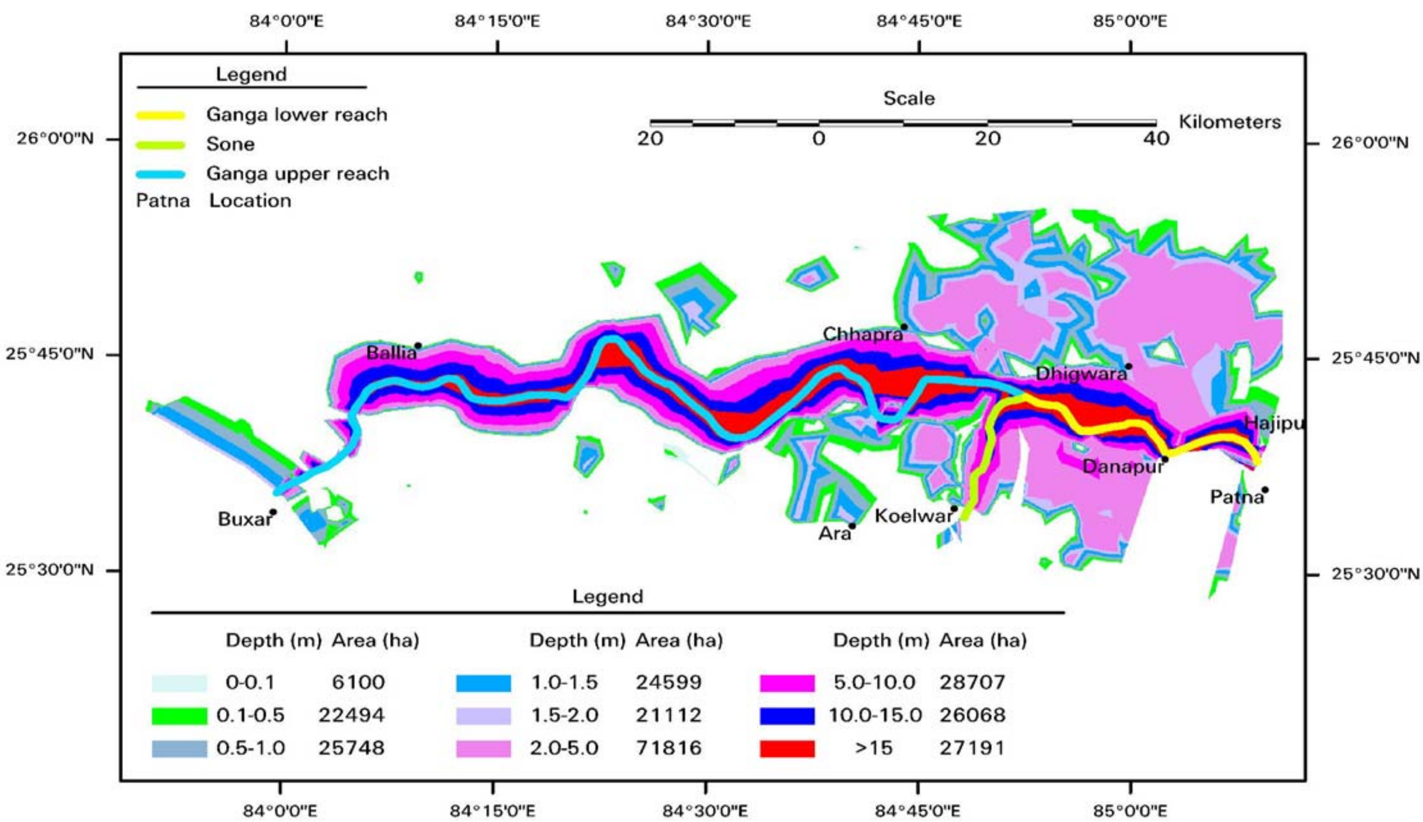
Water surface profile along the river for Sone



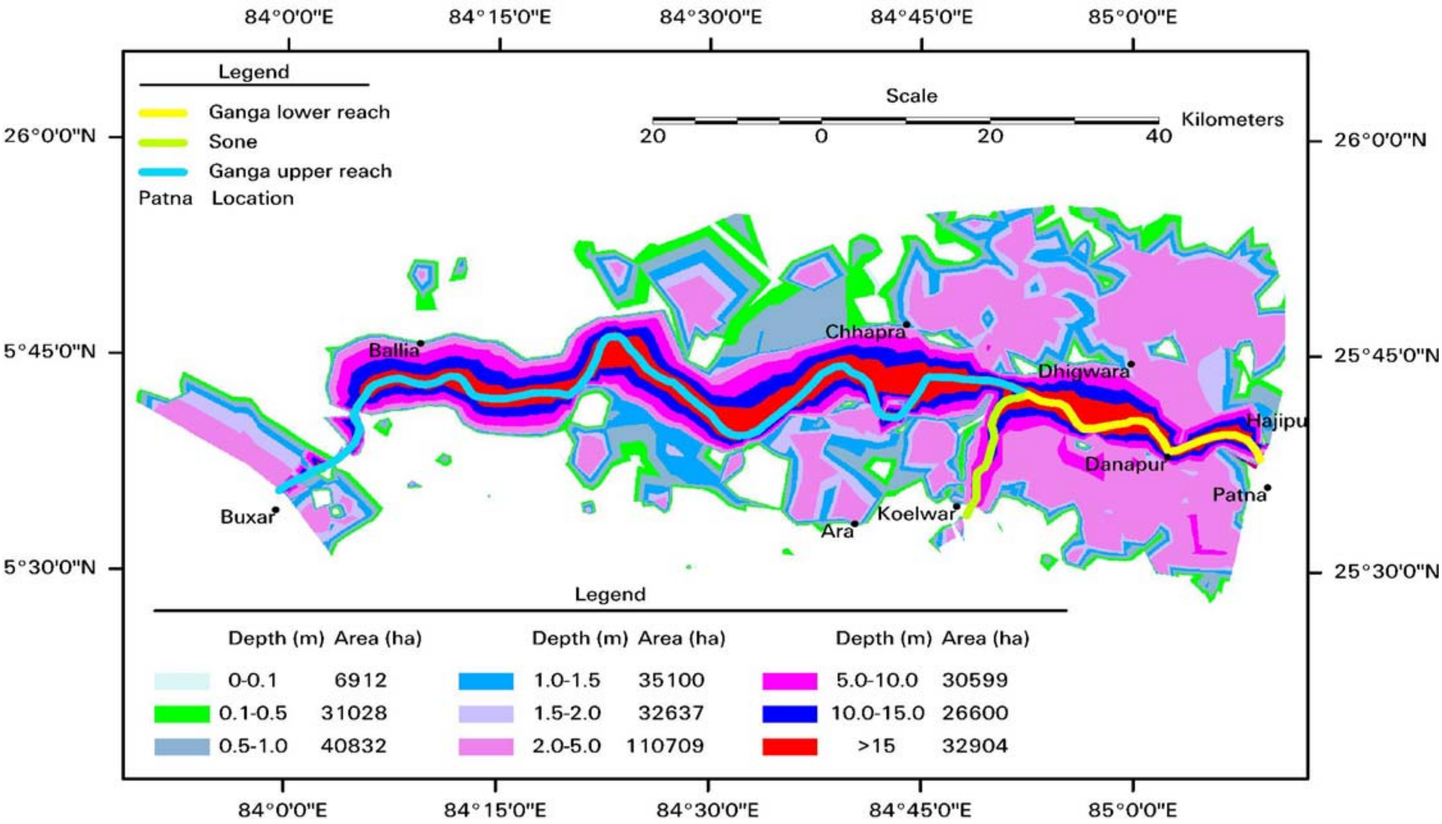
Water depth grids for flood of 1000 Years Return Period



Depth and Areal Extent of flooding for T = 50 years



Depth and Areal Extent of flooding for T = 100 years



Depth and Areal Extent of flooding for T = 1000 years

Table : Inundated areas and depths of flooding corresponding to various return periods (In hectares)

Water depth (m)	Inundated Area for various return periods (in Hectares)							
	2	10	25	50	100	200	500	1000
0.0-0.5	4676	14407	17324	19918	22494	25392	32746	31028
0.5-1.0	4982	15499	19350	22944	25748	28721	36465	40832
1.0-1.5	4352	15921	15701	19414	24599	26841	32190	35100
1.5-2.0	4800	14469	15772	16870	21112	26595	30466	32637
2.0-5.0	17927	40203	50263	57370	71816	83399	99815	110709
5.0-10.0	26617	27178	27372	27490	28707	29506	30132	30599
10.0-15.0	24524	25745	25901	26007	26068	26291	26528	26600
>15	13753	20264	23312	25744	27191	28576	31342	32904

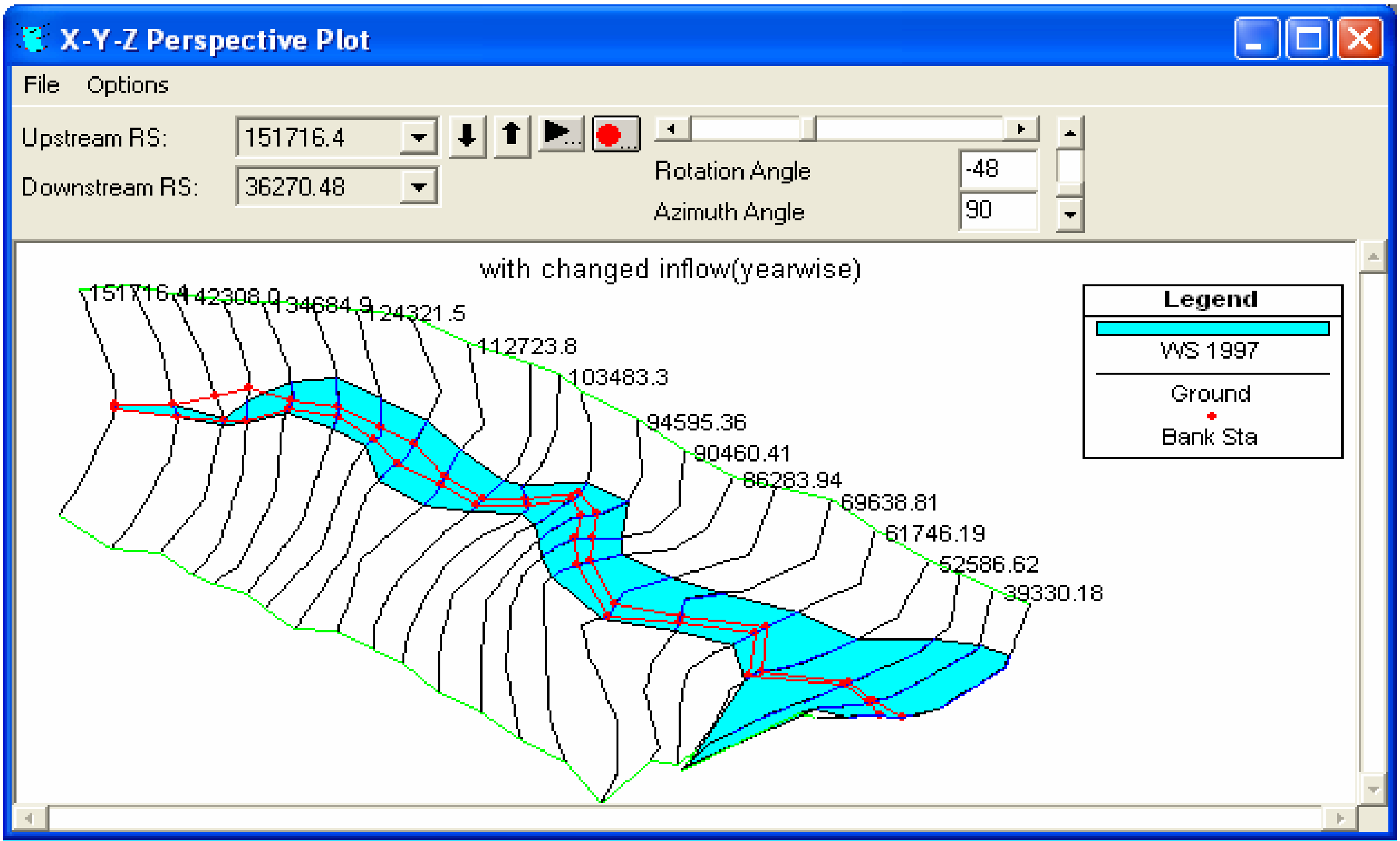


Fig. Simulated water profile for the year 1997

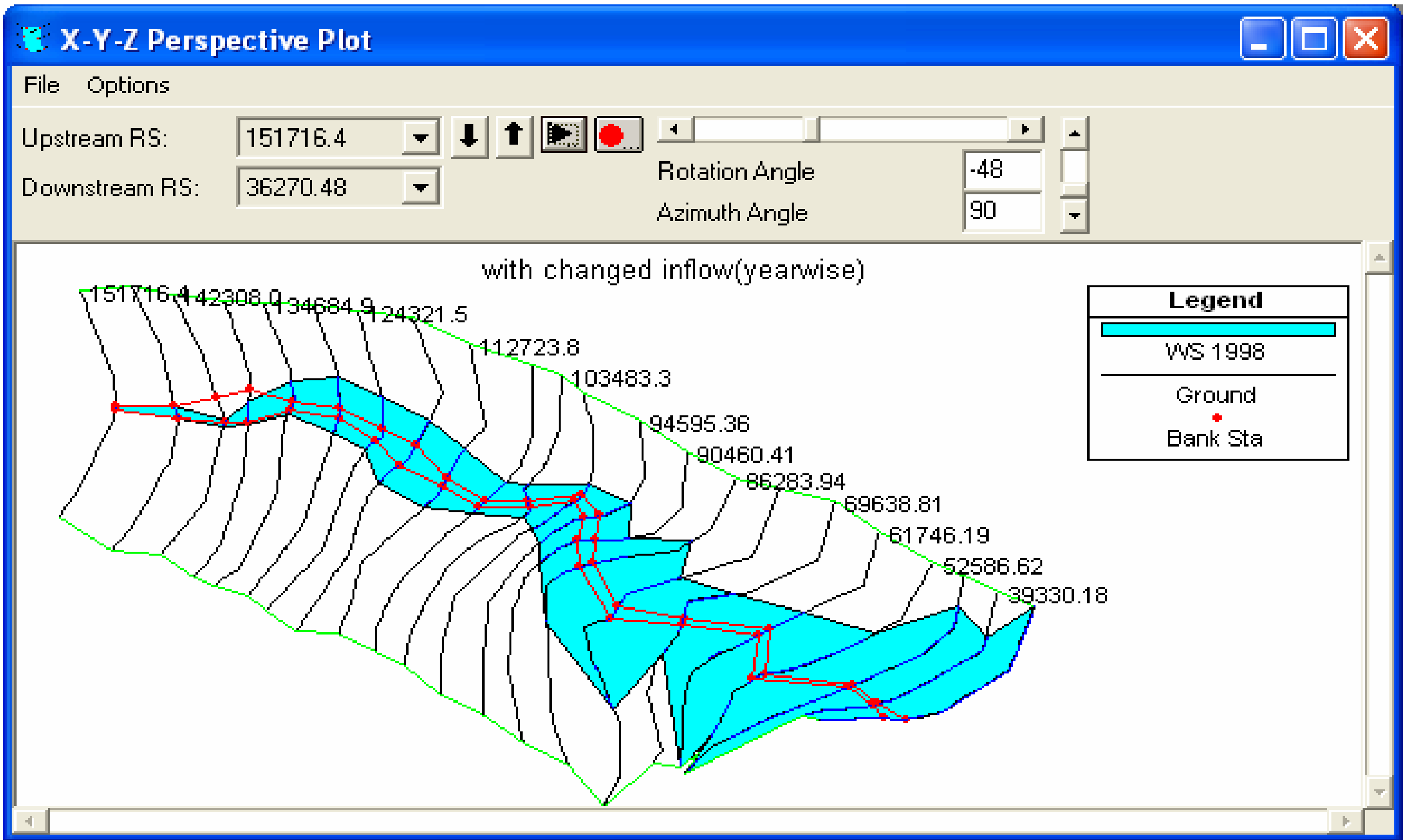


Fig. Simulated water profile for the year 1998

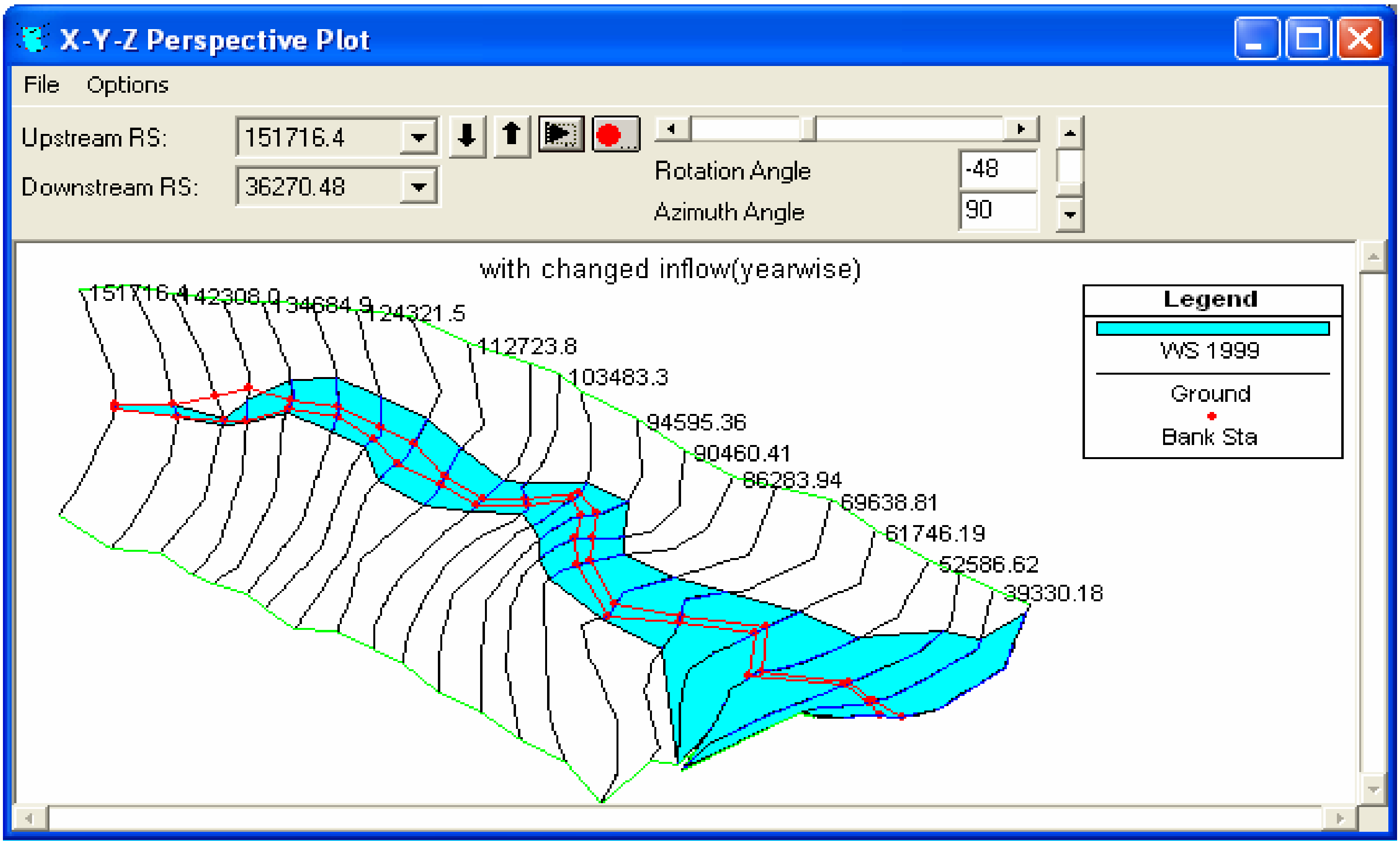


Fig. Simulated water profile for the year 1999

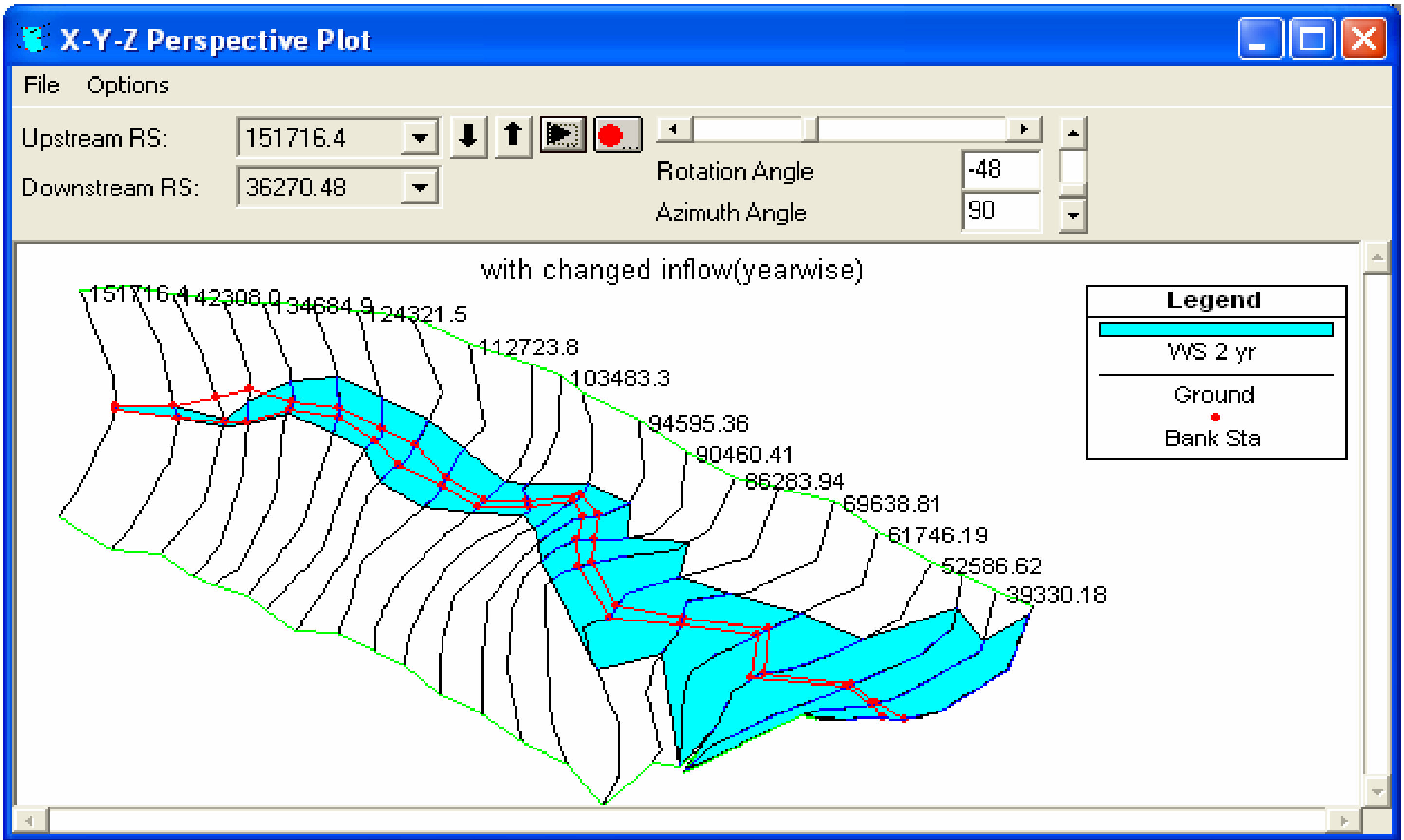


Fig. Simulated water profile for T = 2 years

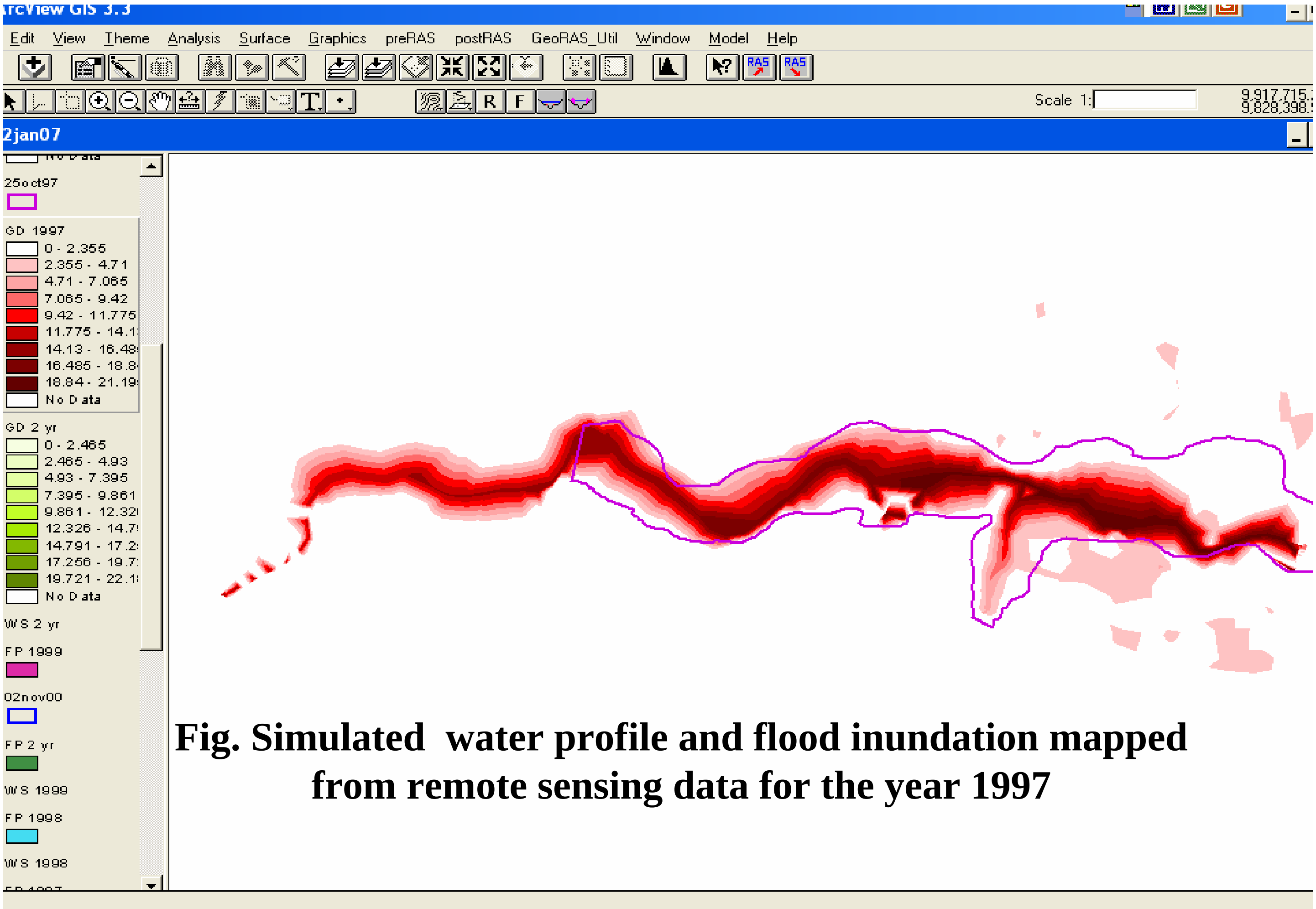


Fig. Simulated water profile and flood inundation mapped from remote sensing data for the year 1997

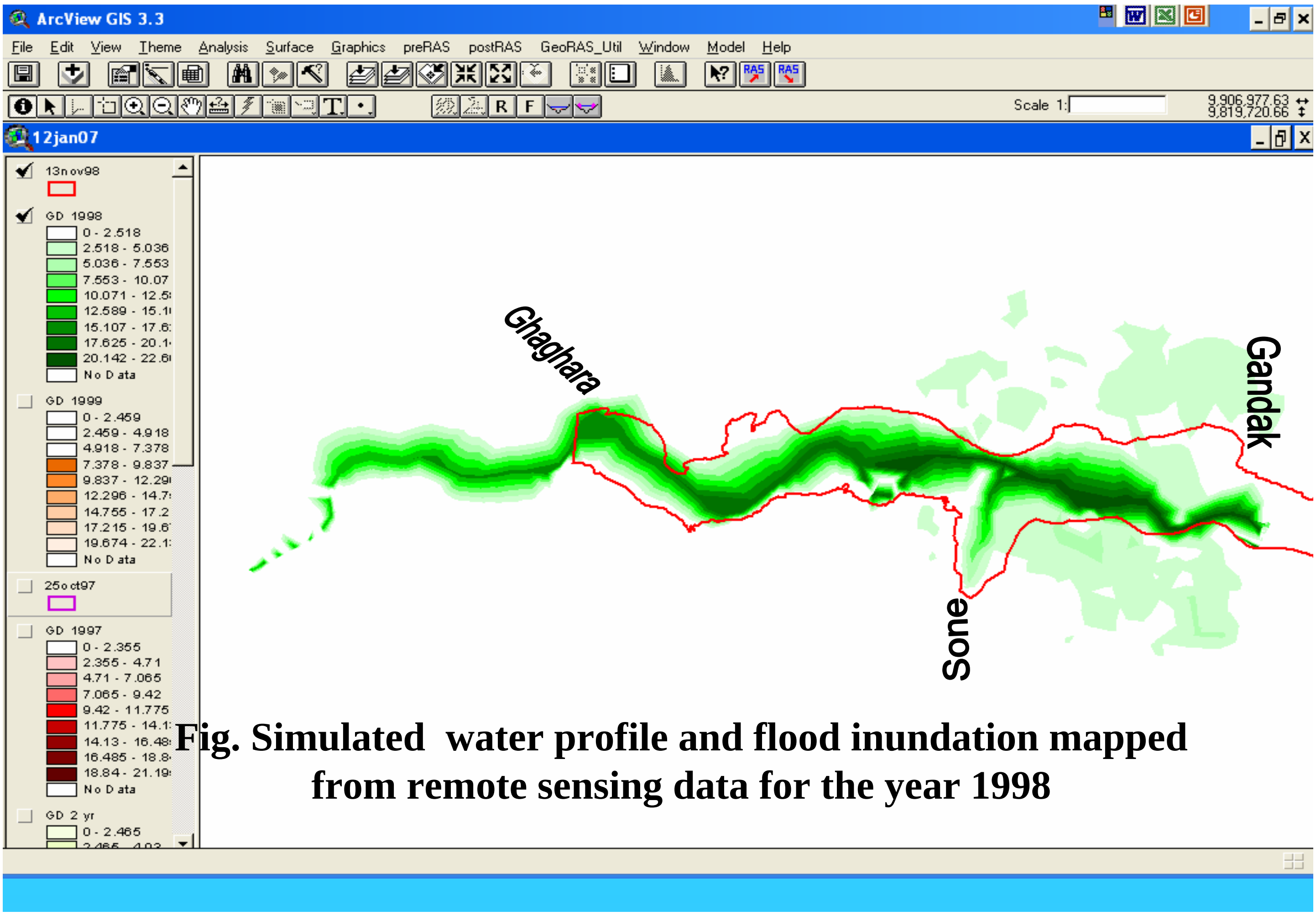


Fig. Simulated water profile and flood inundation mapped from remote sensing data for the year 1998

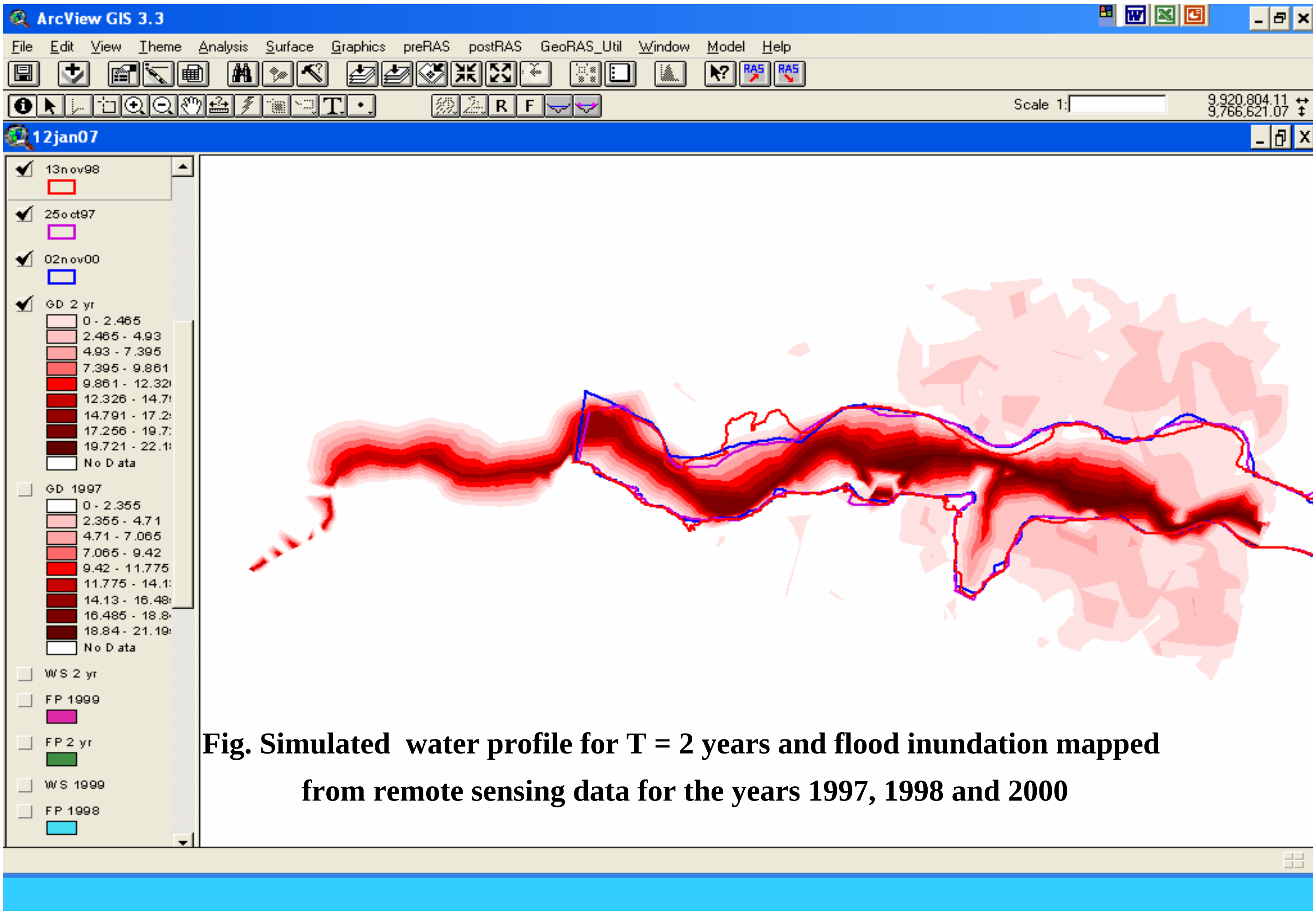


Fig. Simulated water profile for T = 2 years and flood inundation mapped from remote sensing data for the years 1997, 1998 and 2000

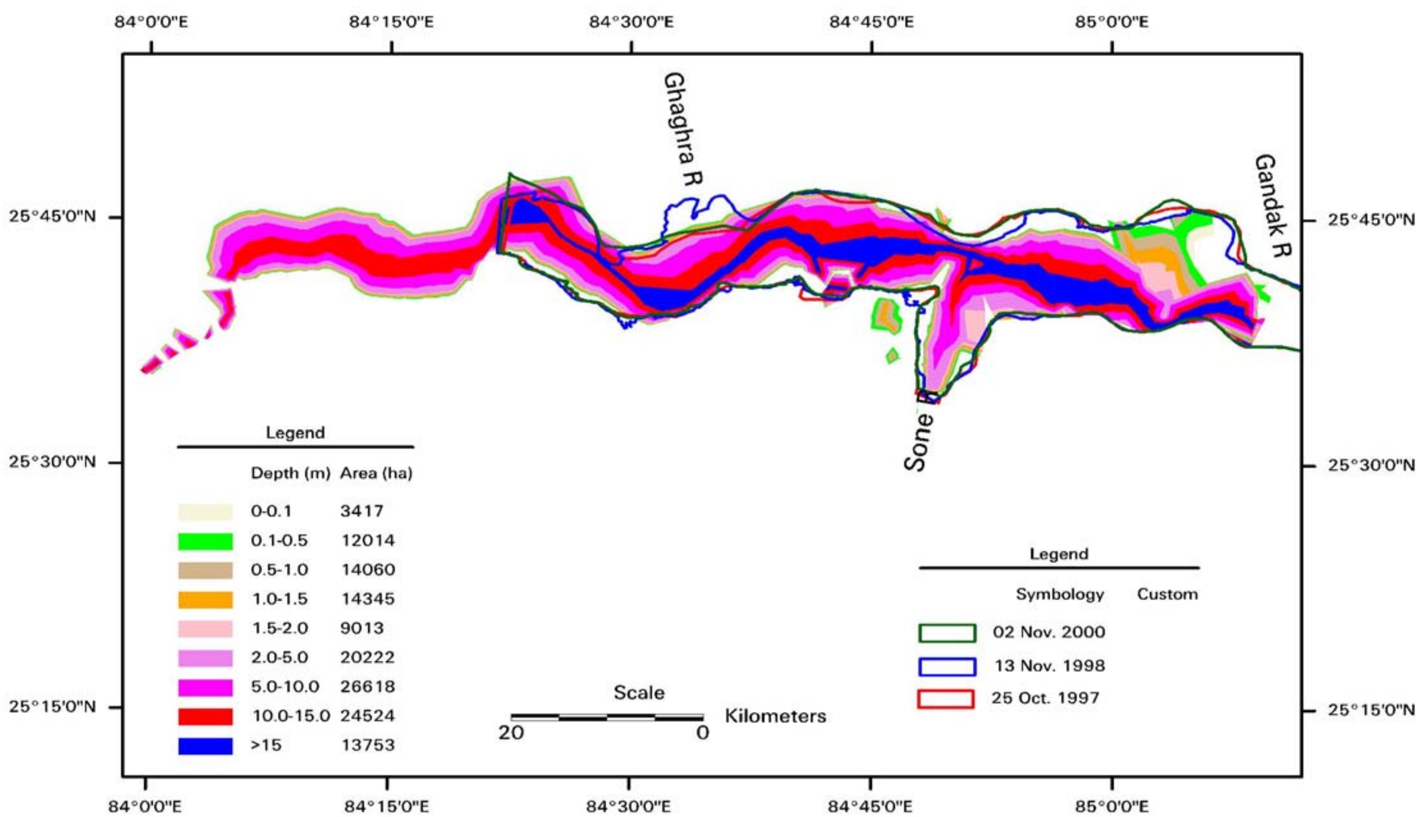


Fig. Comparison of simulated flooding due to two year return flood and flooding due to annual maximum peak floods of the years 1997, 1998 and 2000 mapped from remote sensing data

PERFORMANCE EVALUATION STUDIES

Assessment of the appropriateness of design parameters.

Assessment of durability of the anti-erosion works on the basis of field visits and Satellite data.

Assessment of the impact of anti-erosion works and their objectives in preventing erosion.

Assessment of the impact of anti-erosion works in reducing the erosion in pre and post construction stages in upstream, downstream, opposite or other locations.

Cost –Benefit analysis based on assessed benefits.

Suggestions for maintenance of the works.

DATA REQUIREMENTS

- **Detailed project report (s)**
- **Details of designs and estimated as well as actual costs of the anti-erosion work.**
- **Details of damages if any to anti-erosion works over the years.**
- **Peak of stage and discharge data of the nearest site for 30 years.**
- **Stage-discharge data of the stream flow gauging sites located at or just upstream and down stream of the anti-erosion schemes.**
- **Cross-sections and Longitudinal sections for the stream flow gauging site(s) prior to and after the construction of the project and also at the locations of anti erosion works**
- **Satellite data (to be procured by NIH under the project).**
- **Any other relevant report/information/data pertaining to the scheme under study covering hydrological, economical, social, environmental and other aspects.**

PERFORMANCE EVALUATION STUDIES SPONSORED BY GFCC

- Performance Evaluation Study of Anti-erosion Work at Village Arjunpur in Buxor District of Bihar

- Performance Evaluation Study of Flood Protection Work of Raunahi Embankment from 0.6 km to 1.7 km on the right bank of river Ghaghra in Faizabad District of Uttar Pradesh

THANKS