Capacity Building in Applications of Geoinformatics in Flood Hazard Mapping

by
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Capacity Building Projects in Disasters

Capacity building projects are being sponsored by the Japan Aerospace Exploration Agency (JAXA) in developing countries.

Projects:

- **Flood – 5 Projects (Bangladesh, Cambodia, China, Laos & Nepal)**
- **Landside – 3 Projects (Philippines, Sri Lanka & Vietnam)**
- **Drought – 1 Project (Philippines)**

Activities:

1. Workshop and Training in AIT– Aug/Sep, 2006

2. Field Visit – Nov/Dec, 2006

3. Data Analysis and Report Writing in AIT– Jan/Feb, 2007

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Flood Projects

Sl. No.	Country	Organizations
1	**Bangladesh**	Flood Forecasting & Warning Center (**FFWC**)
		Local Government Engineering Dept. (**LGED**)
		Bangladesh Disaster Preparedness Center (**BDPC**)
2	**Cambodia**	Geography Department, Ministry of Land Administration Urban, Planning and Construction (**MLUPC**)
		Hydrology and Water River Works Dept., Ministry of Water Res. and Meteorology (**MOWRAM**)
3	**China PR**	Beijing Normal University
4	**Lao PDR**	Environmental Research Institute (**ERI**), Science Technology and Environment Agency
		Department of Meteorology and Hydrology (**DMH**)
5	**Nepal**	Department of Water Induced Disaster Prevention (**DWIDP**)
		Survey Department
		Department of Hydrology and Meteorology (**DHM**)

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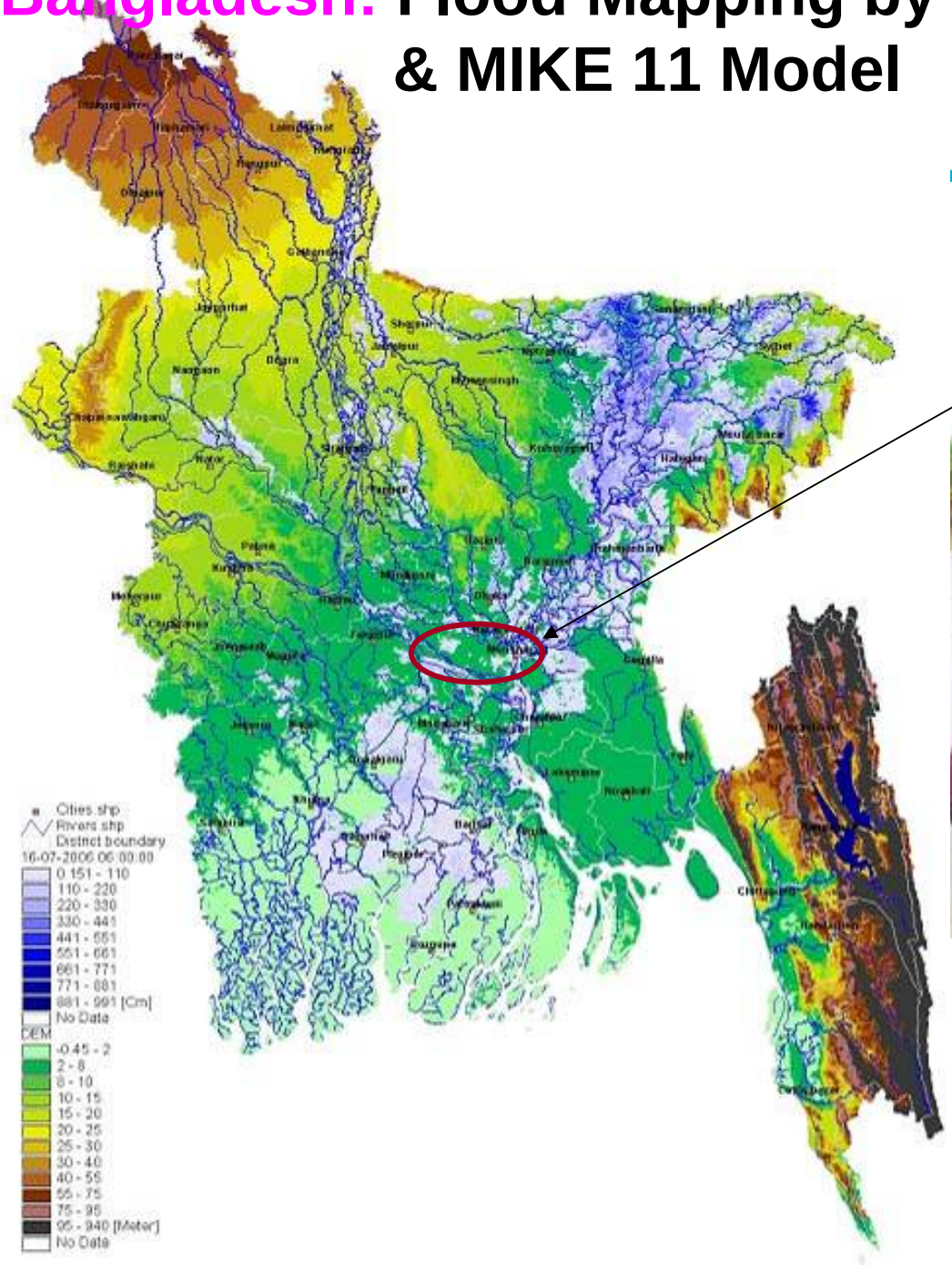
Bangladesh: Flood Mapping by Integrating RS Data & MIKE 11 Model



Munshiganj

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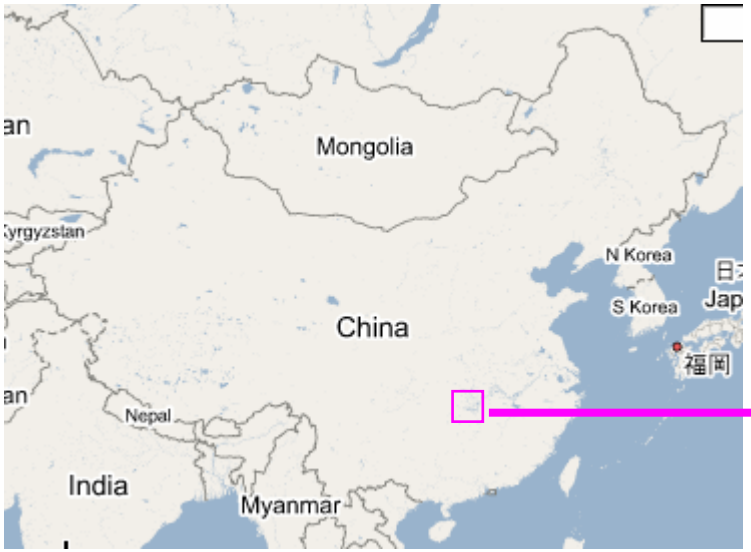
China: Flood Risk Assessment using RS and Hydrologic model in the Xiang Jiang River



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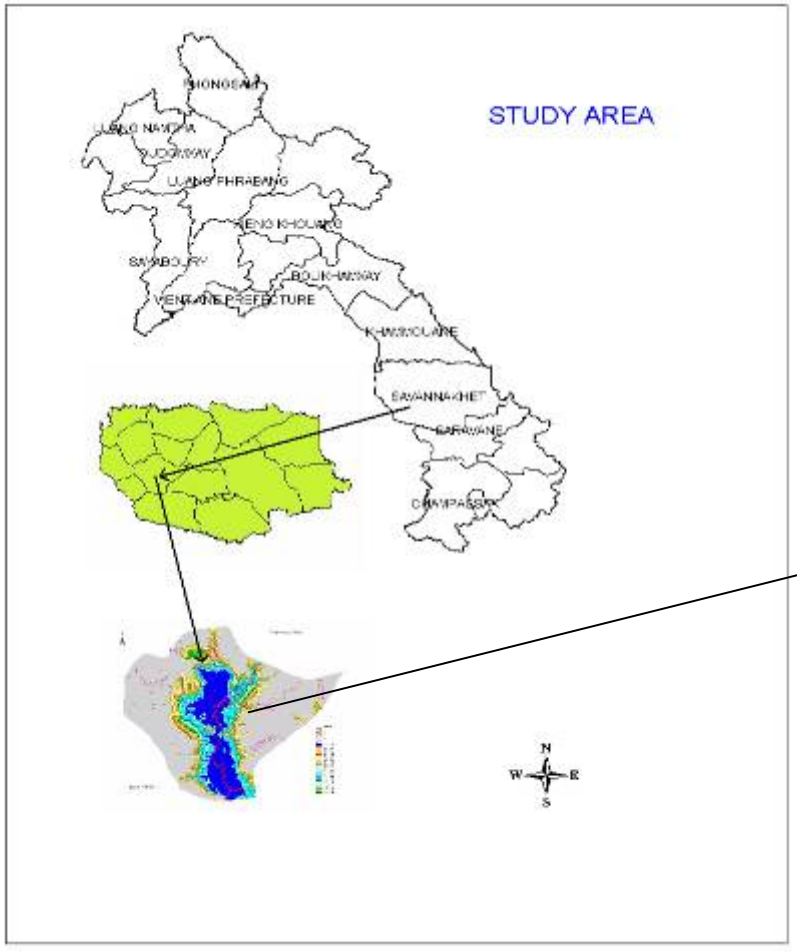
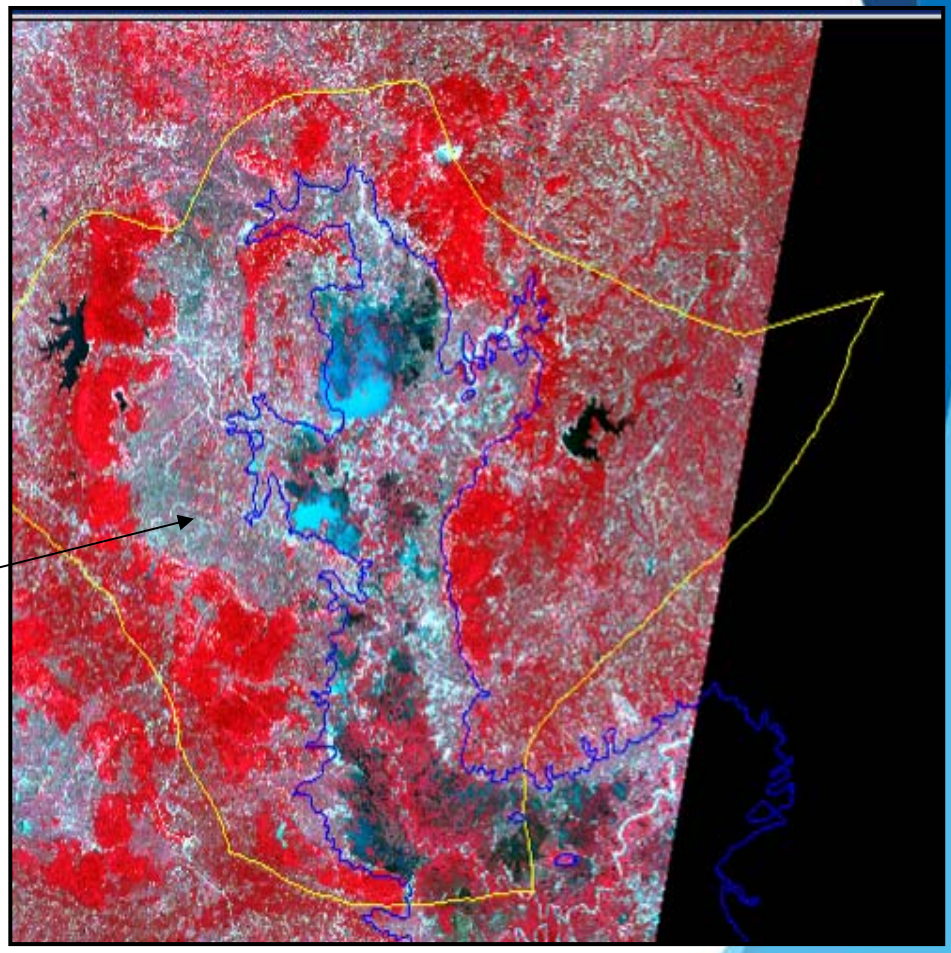
Laos: Application of RS-GIS for Flood Extent Study in Savannakhet Province





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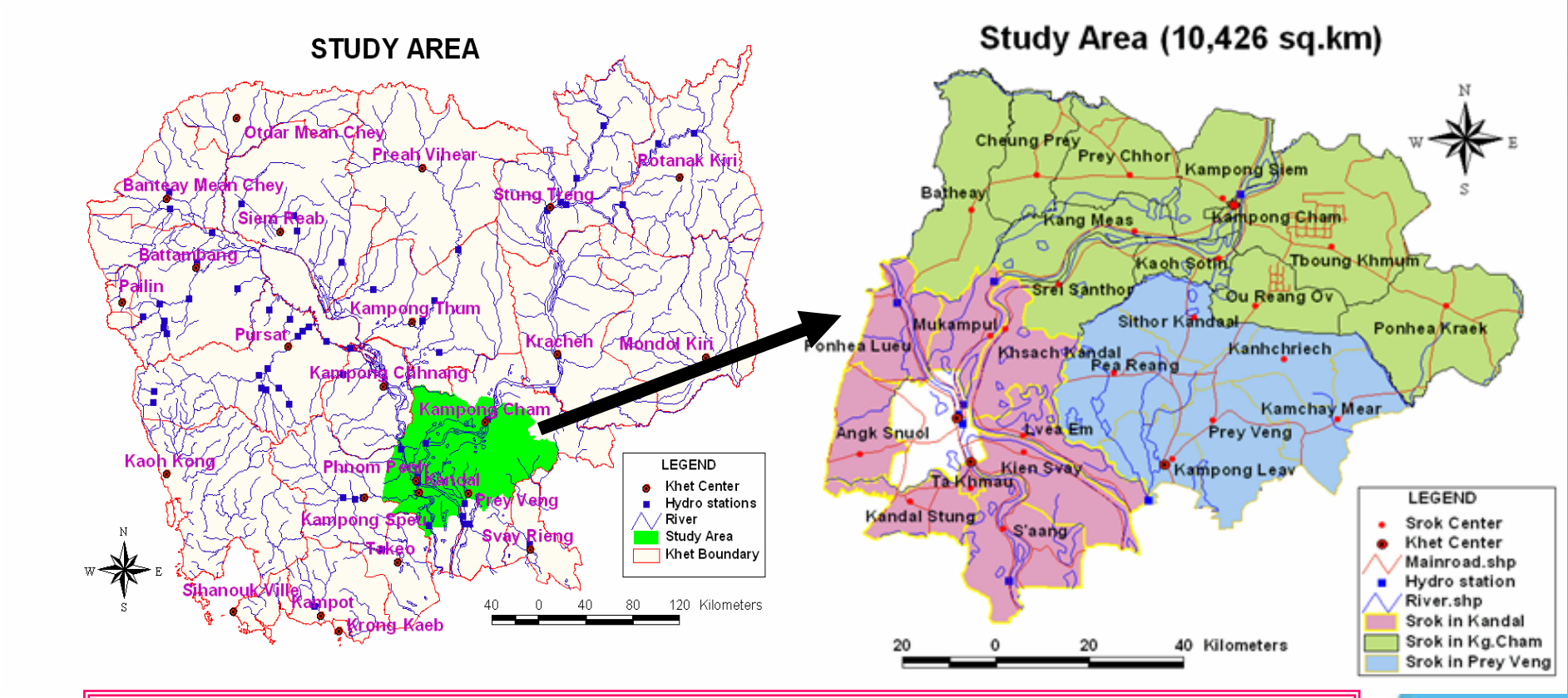
Cambodia

A Detail Example for Flood Hazard Mapping

Study Area



Study area covers 3 provinces (Kompong Cham, Prey Veng, Kandal and Phnom Penh), 26 districts, 305 communes with population 245,086 persons.

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Problem Statement

A number of settlements usually in both banks of the Mekong river are flooded during the rainy season (August-November)

Major Floods in Recent Years

Year 2000

- On 28 Aug., 2000
- 1139 dead, 6,574,000 displaced
- 208200 sq. km area flooded
- Property Damage 78.2 Million US$

Year 2006

- From 10 Aug. to 1 Nov., 2006 (84 days)
- 68 dead, 33,000 displaced
- 143,300 sq. km area flooded

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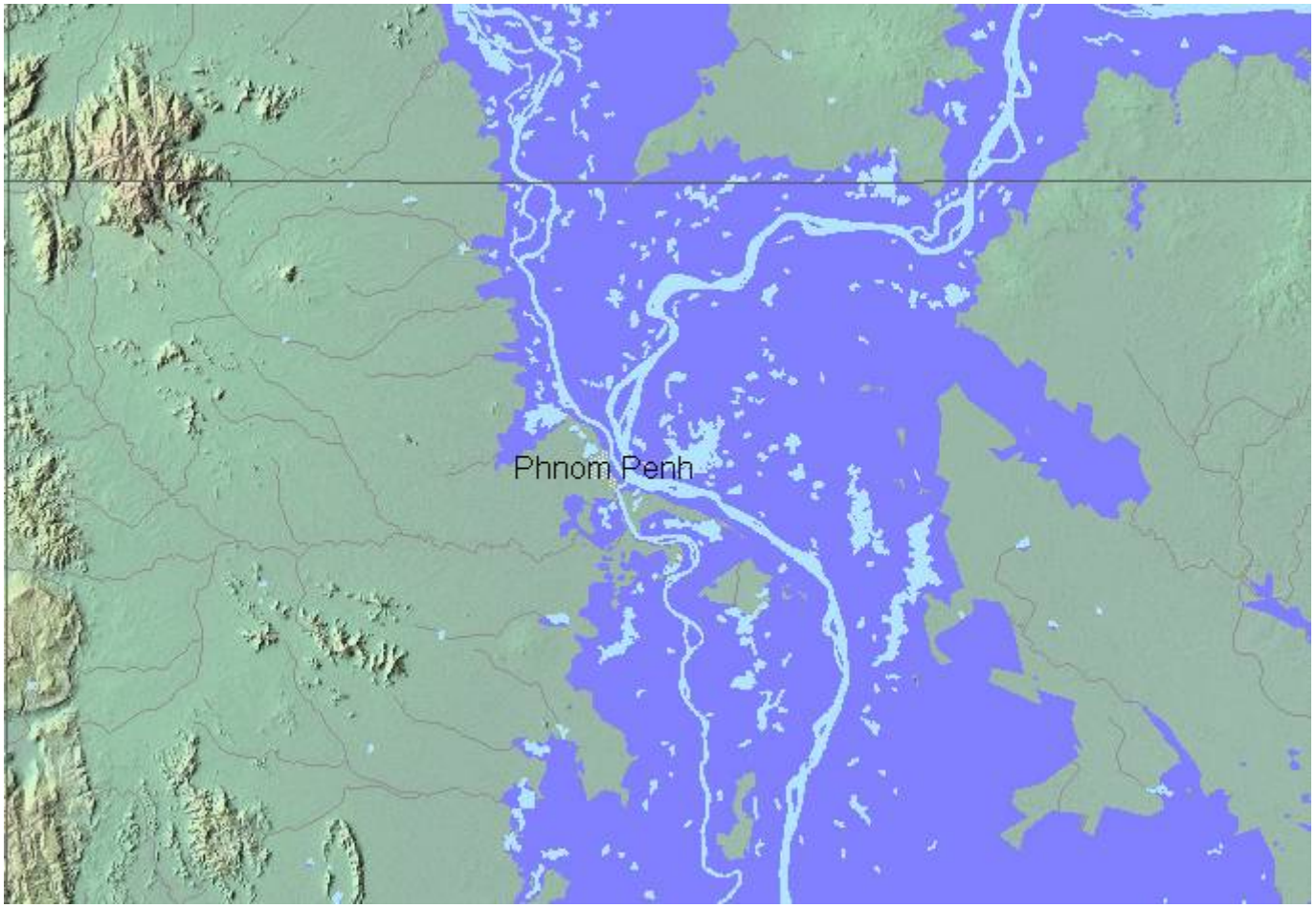
2000 Flood (Dartmouth Flood Observatory)



http://www.dartmouth.edu/~floods/Archives

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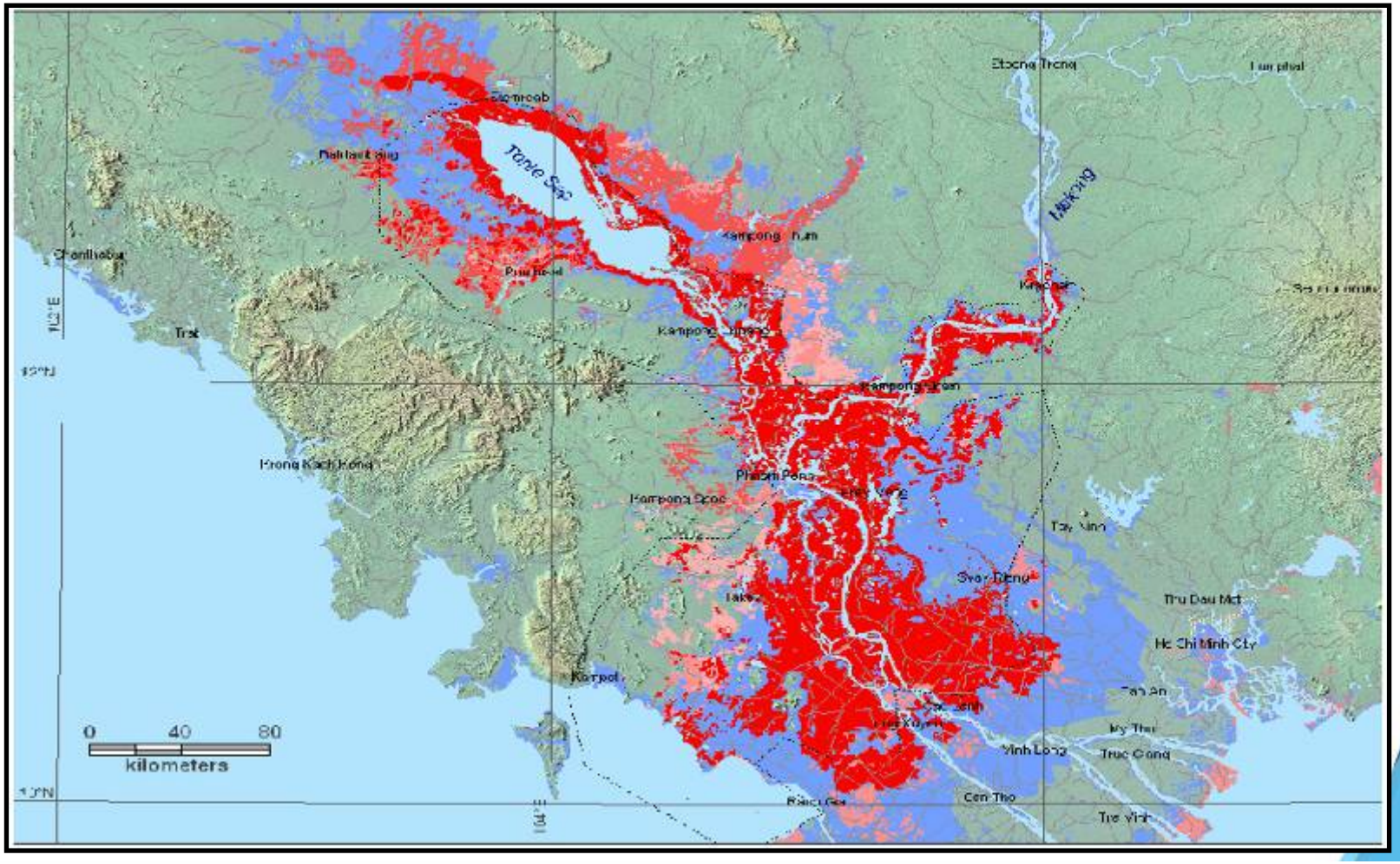
2006 Flood (Dartmouth Flood Observatory)



DFO Event # 2006-173 - Glide #: FL-2006-000130-KHM - Cambodia and Vietnam - Mekong and Tonle Sap Rivers - Rapid Response Inundation Map

MODIS flood inundation limit September 4, 2006:
September 2, 2006:
August 19, 2006:
August 21, 2006:
Maximum Observed Inundation Limit 1999 - 2005:
MODIS cloud free area September 4, 2006:
SWBD reference water:
DCW Rivers: —Urban areas:

Universal Transverse Mercator Zone 48 North - WGS 84
Graticule: 2 degrees
Shaded relief from SRTM data

Dartmouth College - Hanover NH, 03755 USA
Elaine K Anderson - G. R. Brakenridge

Main Objectives of the Study

- To integrate a flood simulation model and remotely sensed data with the available topographic and socio economic data in a GIS environment
- To validate the model by comparing the flood inundation area and depth with the available flood maps and remote sensing image.
- Preparing hazard maps using depth map and the socio-economic data

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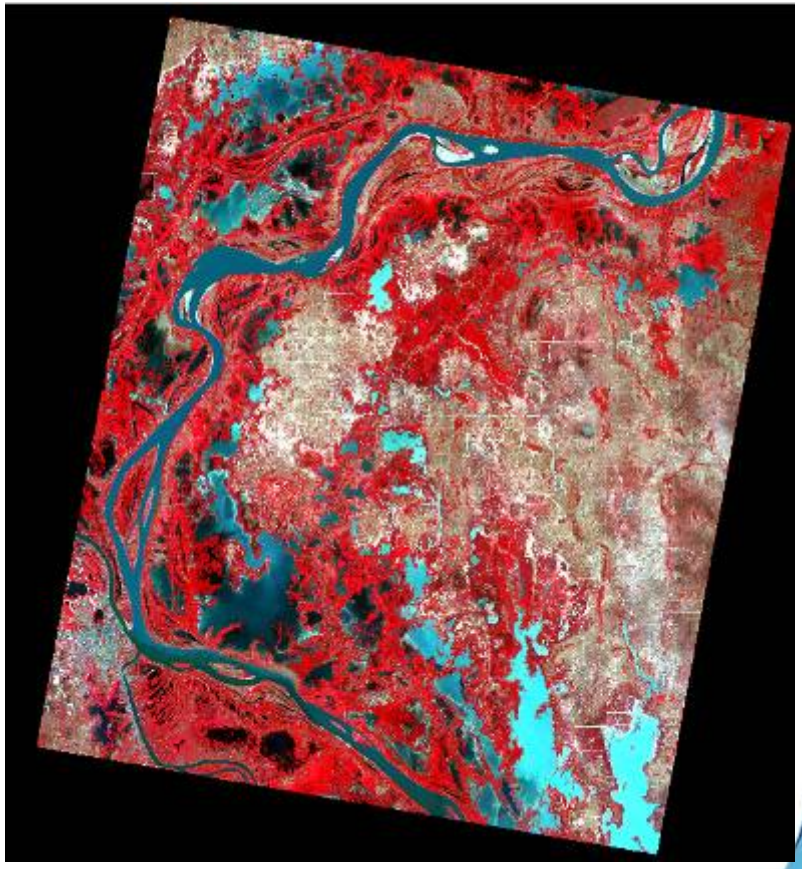
Available Satellite Data of Study Area

Landsat 03-Jan-2005



Aster 06-Jan-2003

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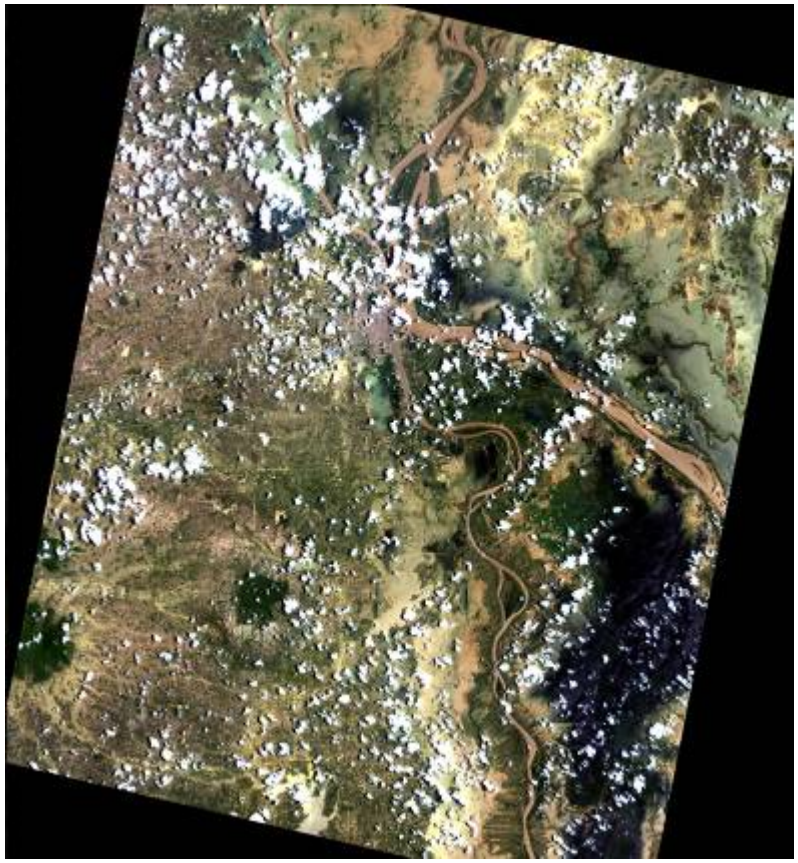
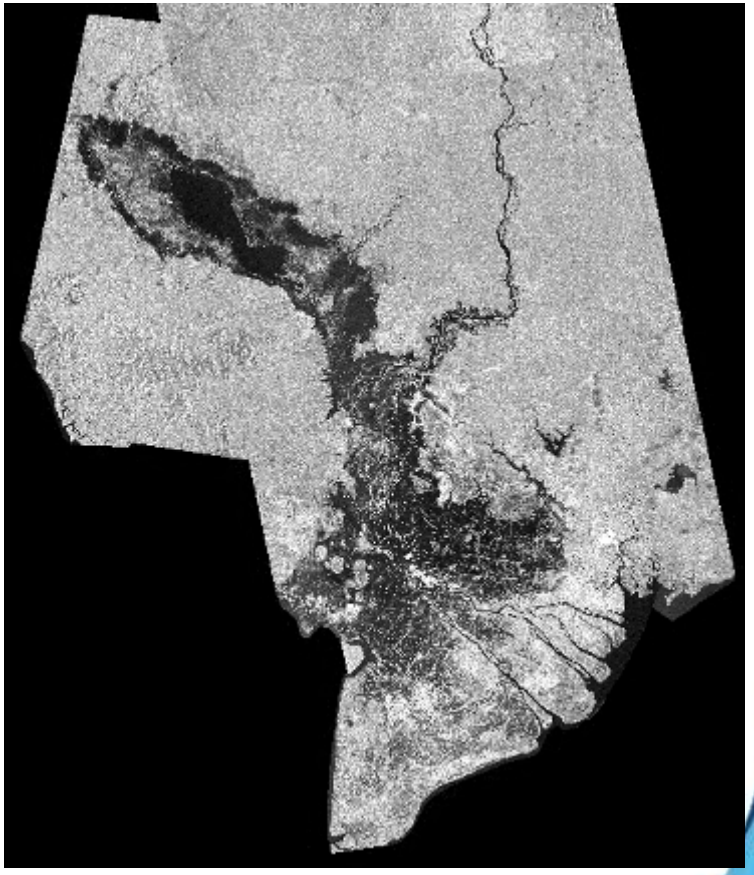
Available Satellite Data of Study Area



ALOS Sensor AVNIR-2

Level-1B2 Date:27 Aug, 06



Radarsat 23 & 25 Sep. and 05 Oct. 2000, Band-C Source :LIDER Project, MRC Secretariat

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Available hydrological data for study

- Daily average river discharge data (m^3/s) (Kampong Cham and Chroui Changvar) (from 1991 to 2002)
- Water surface heights (MSL) (Kampong Cham and Chroui Changvar) (1991 to 2002)
- Manning's co-efficient of Roughness for the River bed and the flood plain derived from the landuse map.

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Available ancillary data for study

- Census data
- Socio-Economic data (CELA Program, UNDP)
- Spot heights of the flood plain/river bed
- Topographic maps (1:50,000) (Geography Department)
- Administrative and other vector maps

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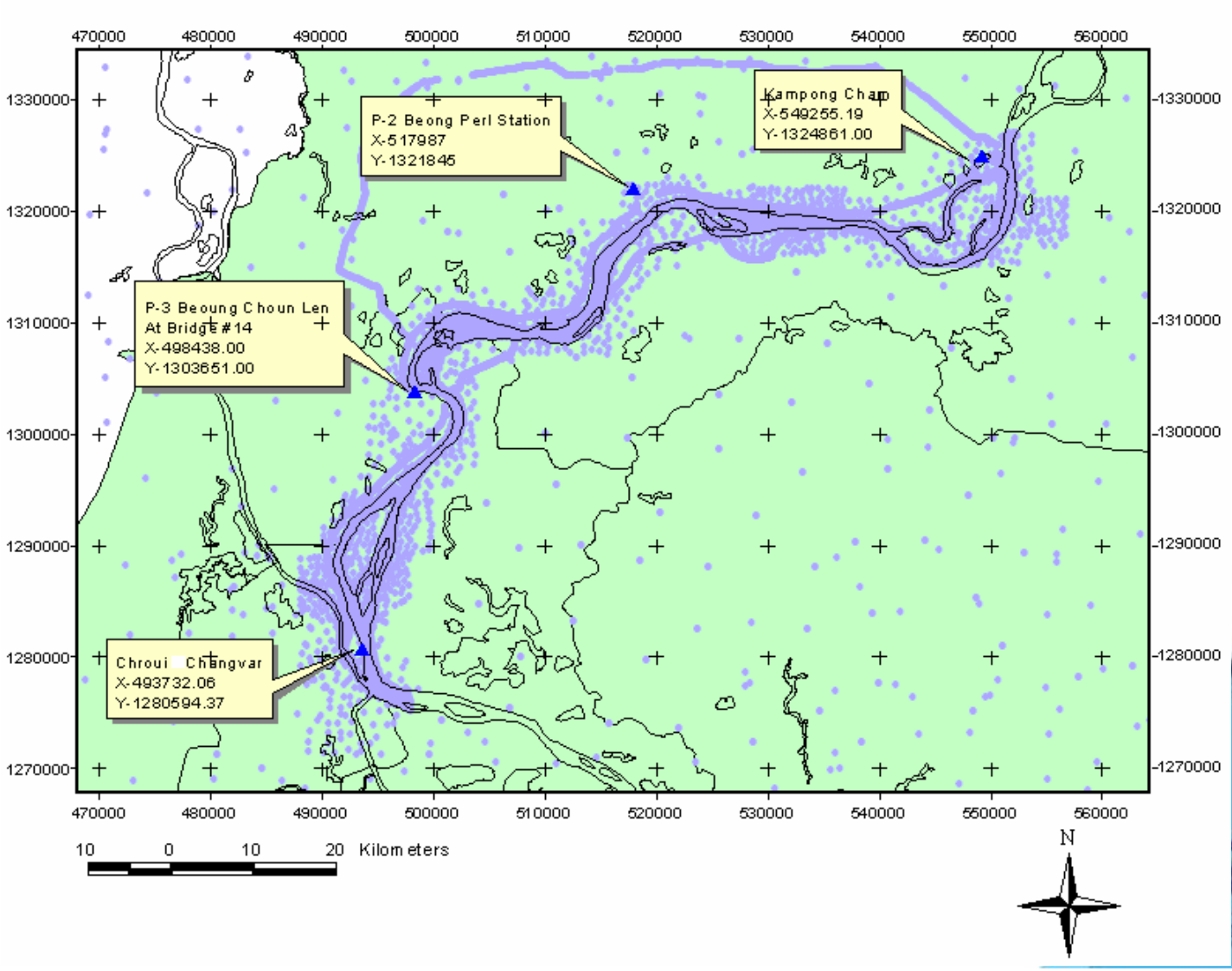
Hydrological stations



Hydrological Data: Peak Discharge

Microsoft Excel - QKampongCham

File Edit View Insert Format Tools Data Window Help

P3535

	A	B	C	D	E	F
1	Dates	Q in m³/s		Dates	Q in m³/s	
3533	1-Sep-00	51881		30-Sep-00	37957	
3534	2-Sep-00	53491		29-Sep-00	39625	
3535	3-Sep-00	55030		28-Sep-00	41328	
3536	4-Sep-00	57050		27-Sep-00	43472	
3537	5-Sep-00	57735		26-Sep-00	45345	
3538	6-Sep-00	57614		25-Sep-00	47655	
3539	7-Sep-00	56492		24-Sep-00	49809	
3540	8-Sep-00	56455		1-Sep-00	51881	
3541	9-Sep-00	57155		23-Sep-00	52111	
3542	10-Sep-00	57631		22-Sep-00	53279	
3543	11-Sep-00	57756		2-Sep-00	53491	
3544	12-Sep-00	57391		21-Sep-00	54438	
3545	13-Sep-00	56863		3-Sep-00	55030	
3546	14-Sep-00	56712		20-Sep-00	55435	
3547	15-Sep-00	56959		8-Sep-00	56455	
3548	16-Sep-00	57184		7-Sep-00	56492	
3549	17-Sep-00	57359		19-Sep-00	56552	
3550	18-Sep-00	57370		14-Sep-00	56712	
3551	19-Sep-00	56552		13-Sep-00	56863	
3552	20-Sep-00	55435		15-Sep-00	56959	
3553	21-Sep-00	54438		4-Sep-00	57050	
3554	22-Sep-00	53279		9-Sep-00	57155	
3555	23-Sep-00	52111		16-Sep-00	57184	
3556	24-Sep-00	49809		17-Sep-00	57359	
3557	25-Sep-00	47655		18-Sep-00	57370	
3558	26-Sep-00	45345		12-Sep-00	57391	
3559	27-Sep-00	43472		6-Sep-00	57614	
3560	28-Sep-00	41328		10-Sep-00	57631	
3561	29-Sep-00	39625		5-Sep-00	57735	
3562	30-Sep-00	37957		11-Sep-00	57756	
3563	1-Oct-00	36735		31-Oct-00	18741	
3564	2-Oct-00	36195		30-Oct-00	18977	
3565	3-Oct-00	34799		29-Oct-00	19877	

Available data From (1991 to 2002)

Source: Dept. of hydrology and river works, Ministry Of Water Resources and Meteorology, Cambodia

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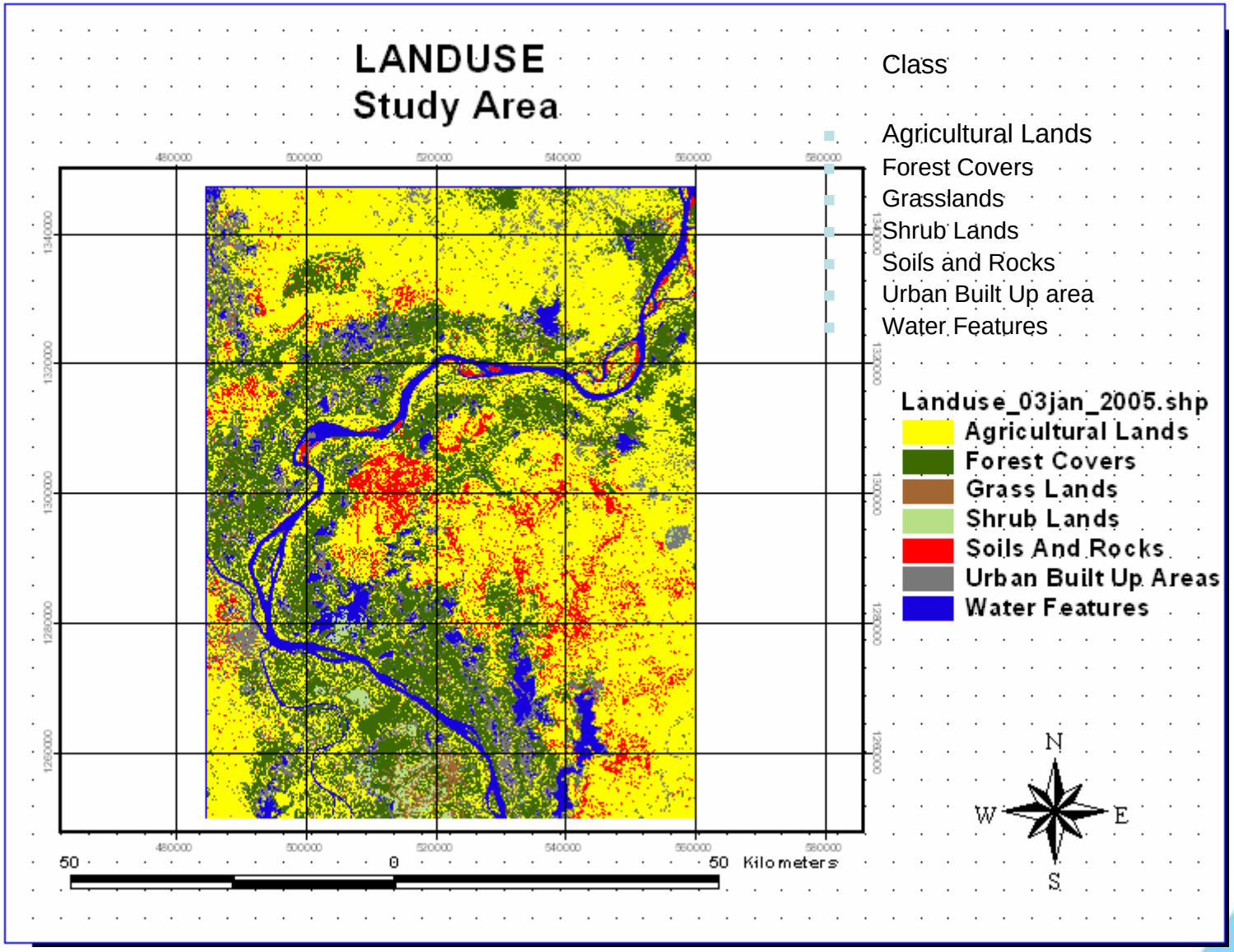
Landuse Map



Class	Manning's Value
Agricultural Lands	0.04
Forest Covers	0.05
Grasslands	0.03
Shrub Lands	0.035
Soils and Rocks	0.038
Urban Built Up area	0.160
Water Features	0.025

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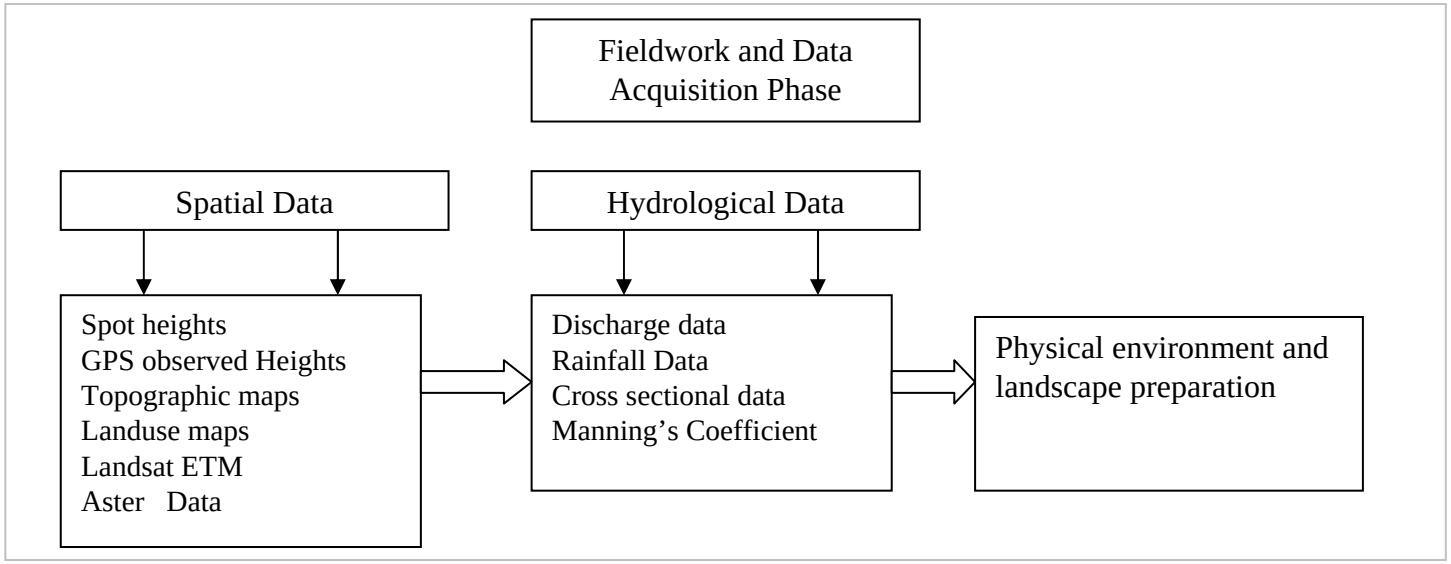
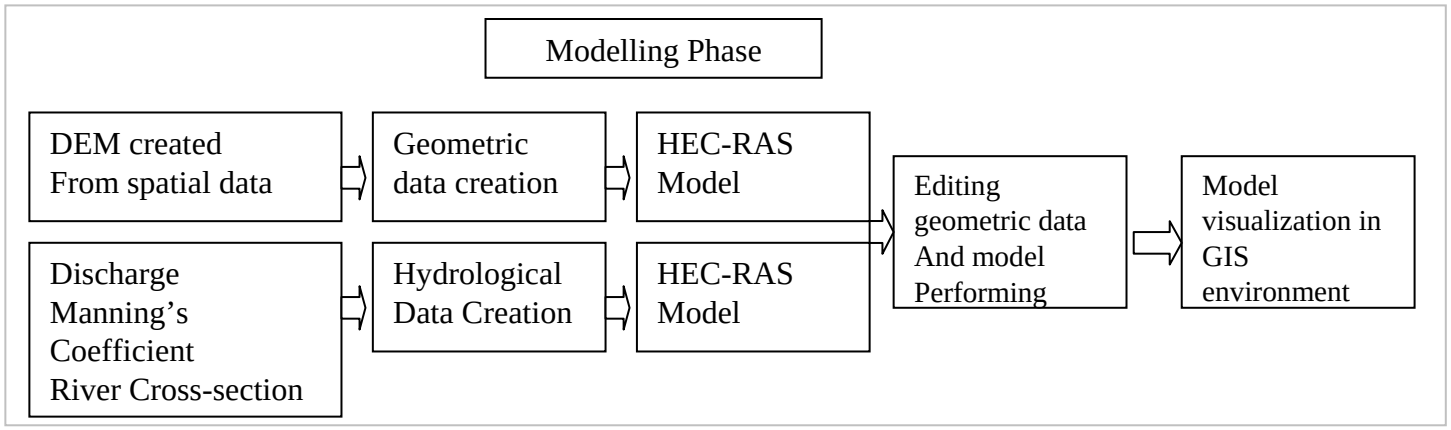
Methodology





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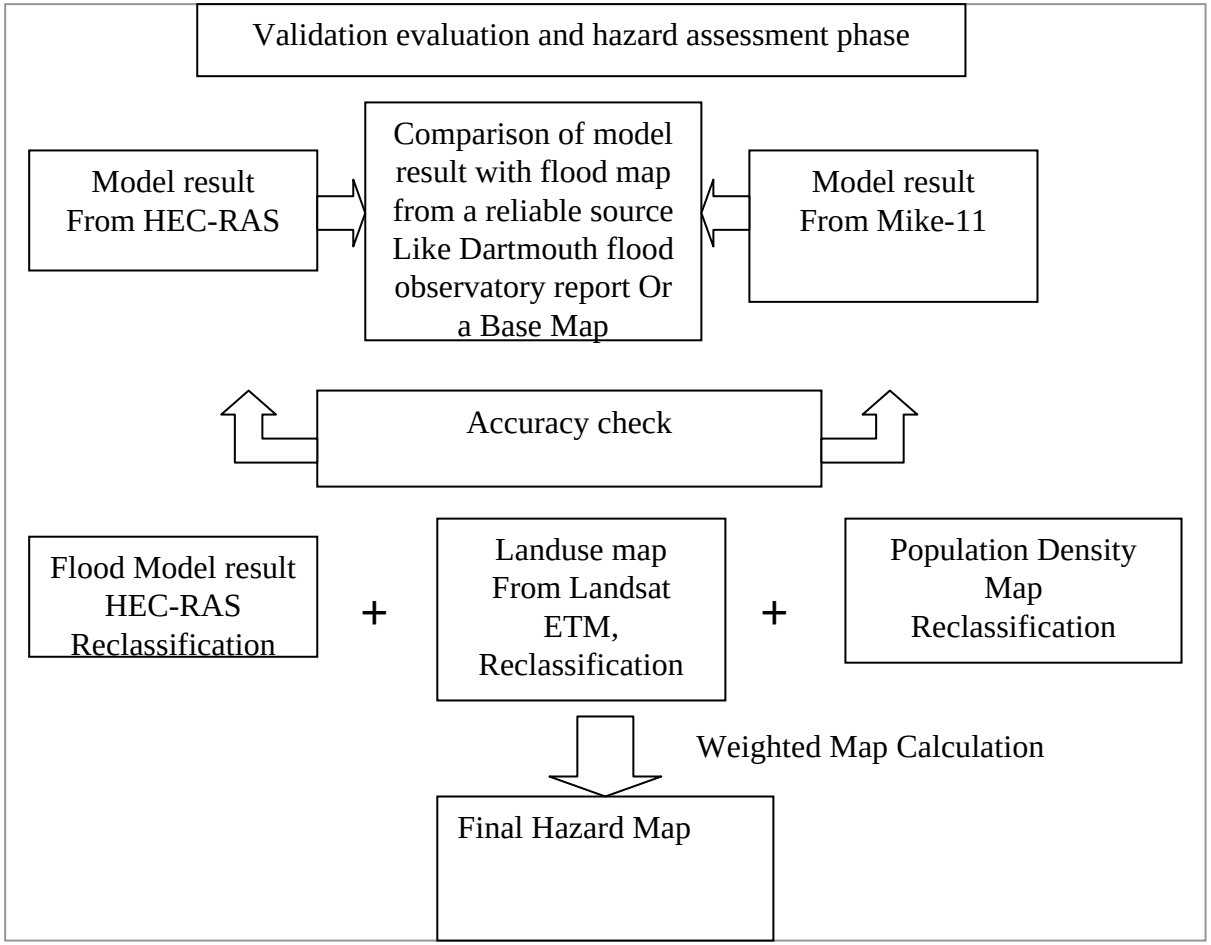
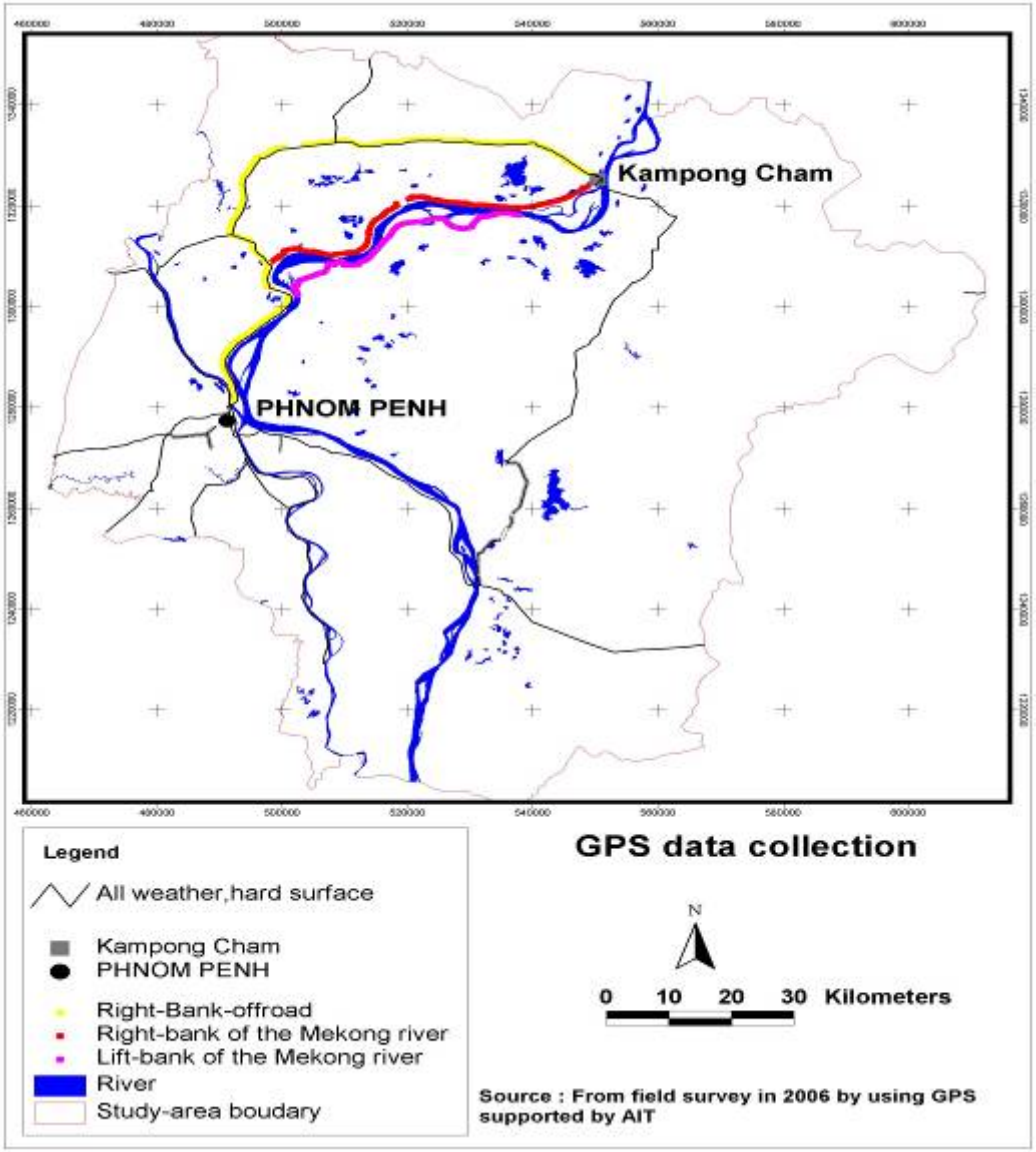
Methodology contd.



Field Survey



Right Bank: **95.15Km**
Left Bank: **43.62 Km**
PP-Kg.Cham:

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During Field Survey

Field Work, Right River Bank

Heavy rain on the way to Kampong Cham

Discussion During the Work

Not only GPS field Work

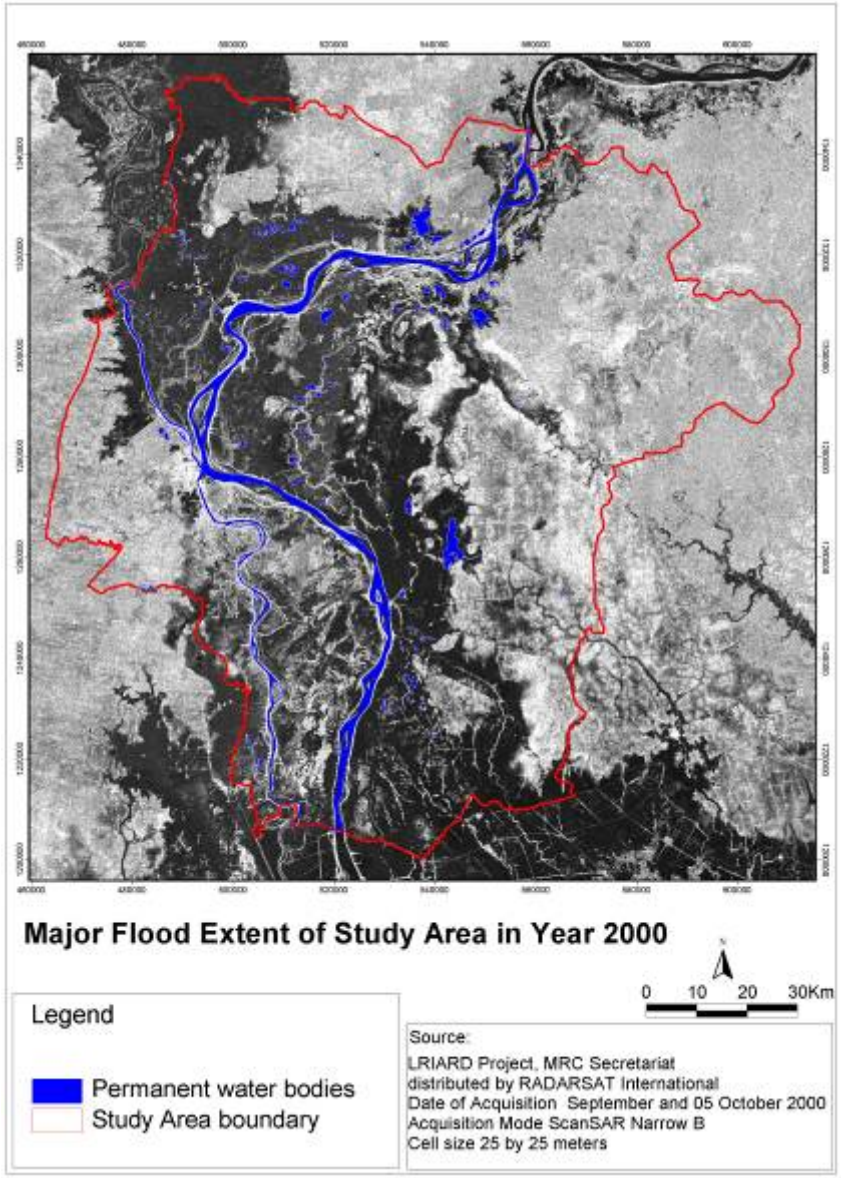
No Other Road Better than this

Getting ready to field work

Off the river bank- No flood

Oh, Yes we all did that

2000 Flood – RADARSAT Image



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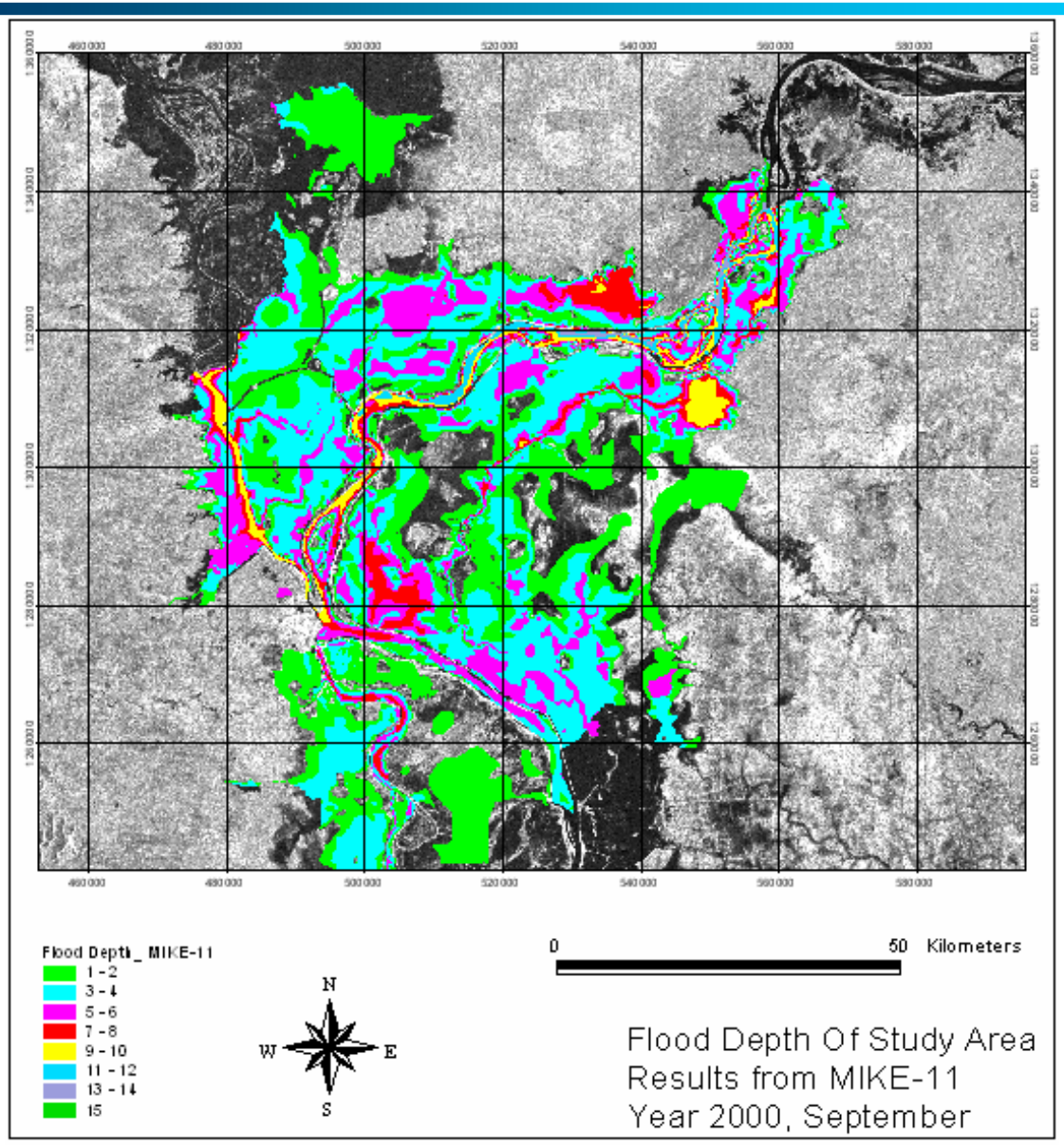
2000 Flood – Overlaying Mike-11 Model Results



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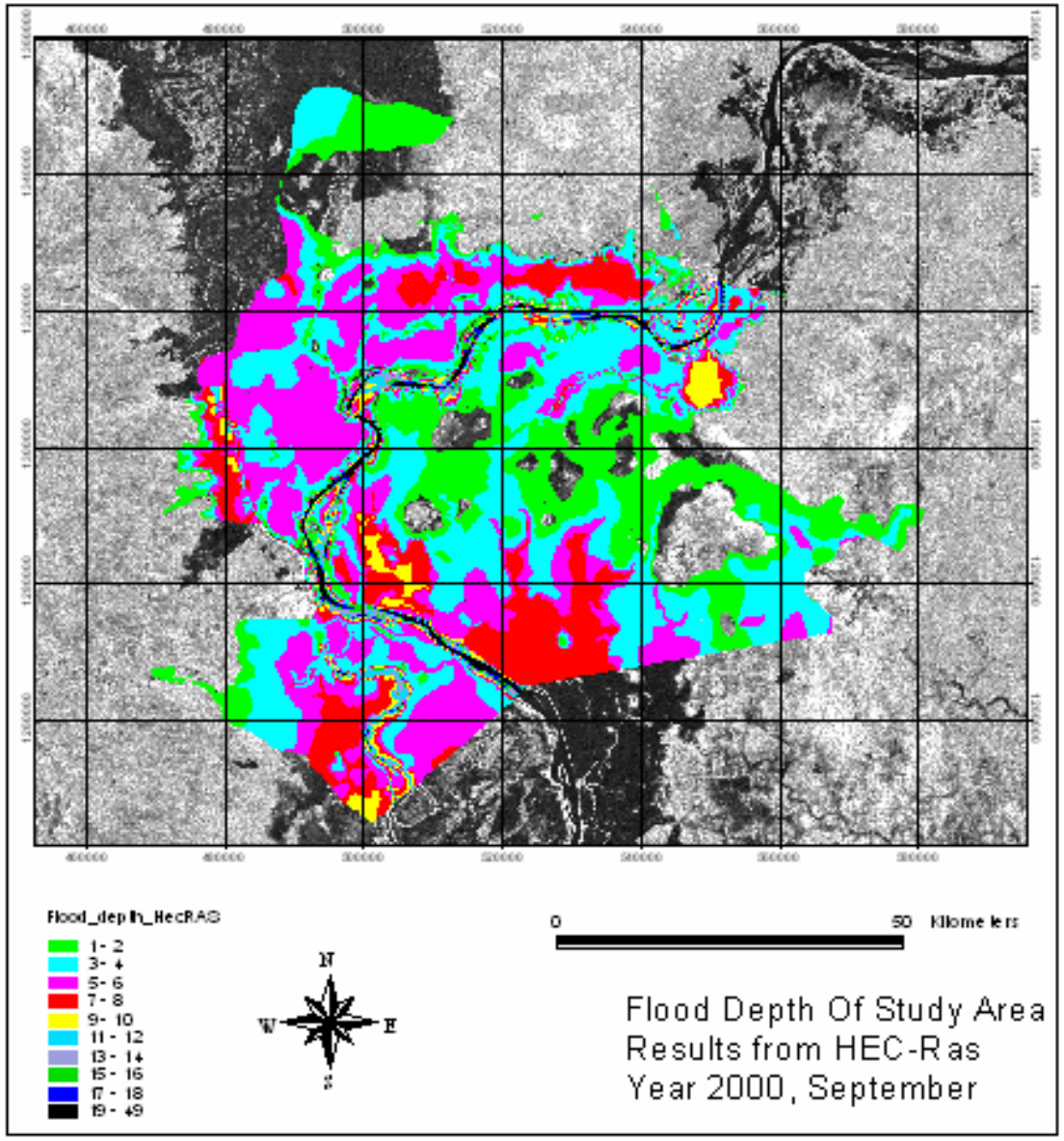
2000 Flood – Overlaying HEC-RAS Model Results



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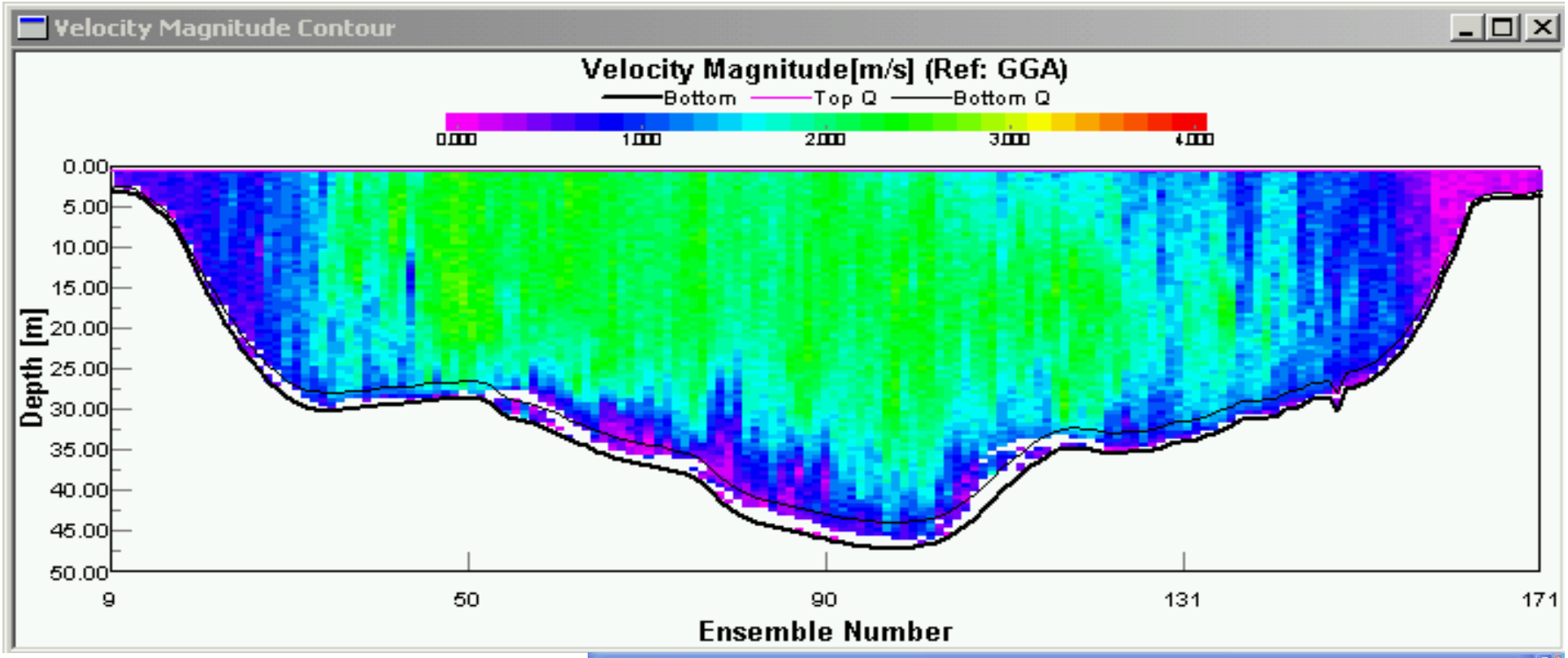
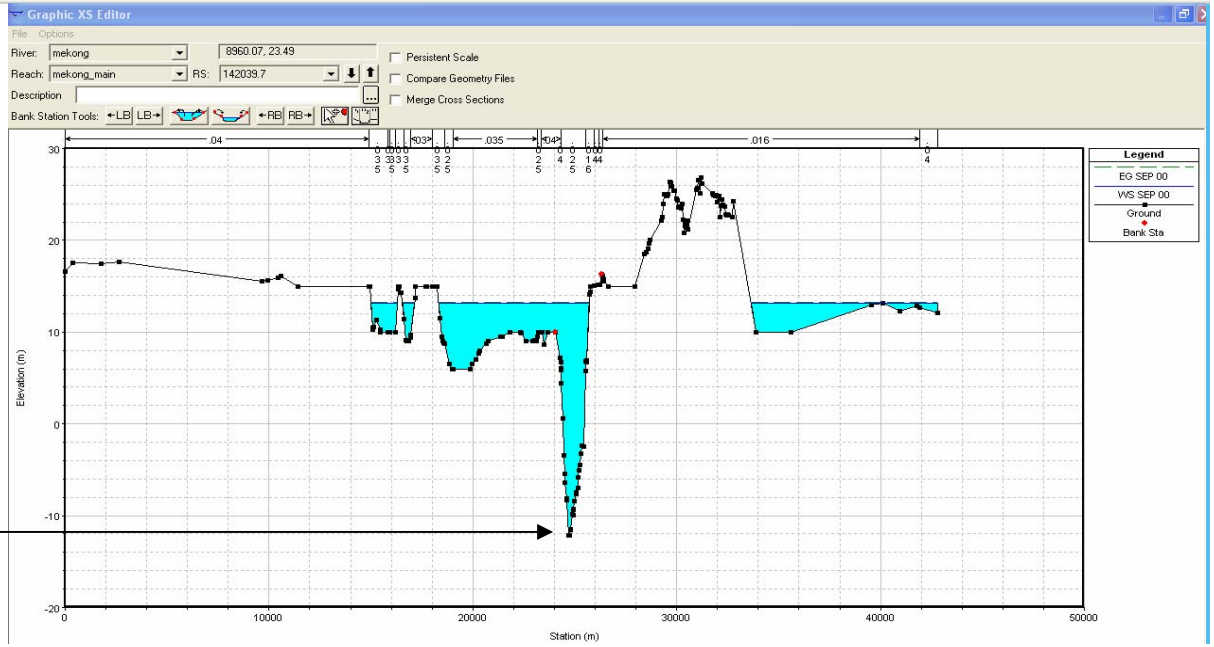


Cross section

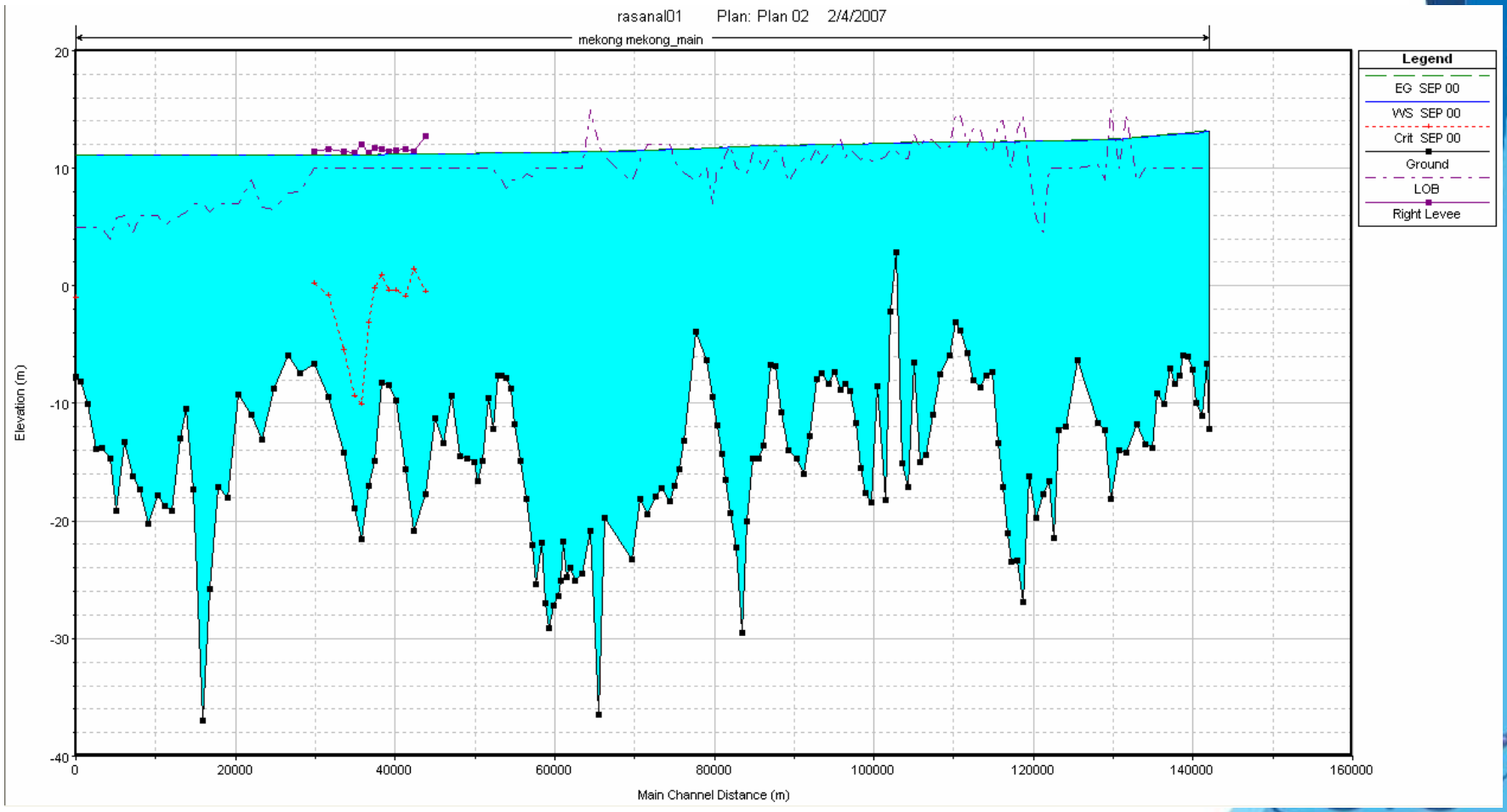
At

Kampong Cham

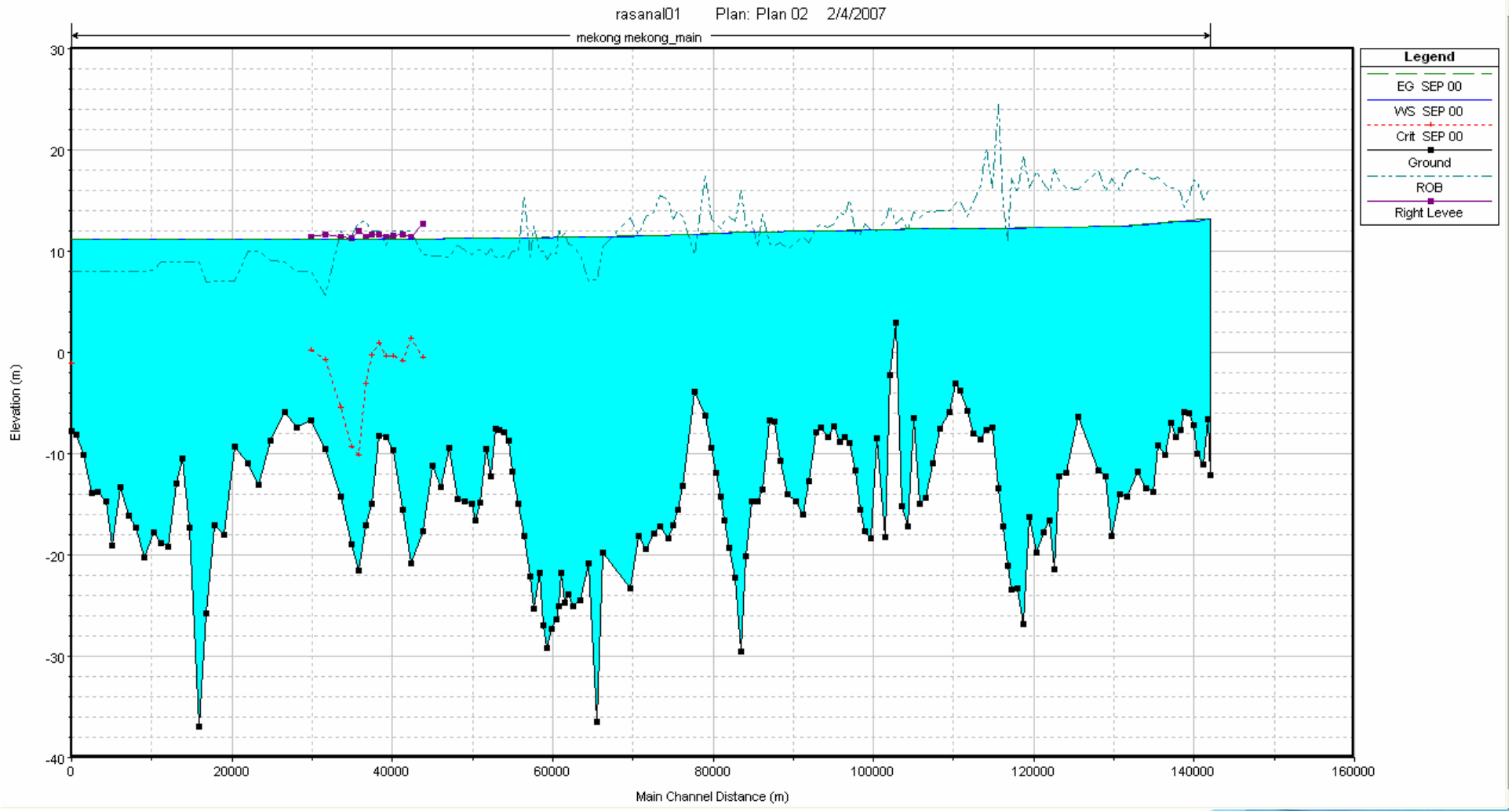


Max. Depth=30 m

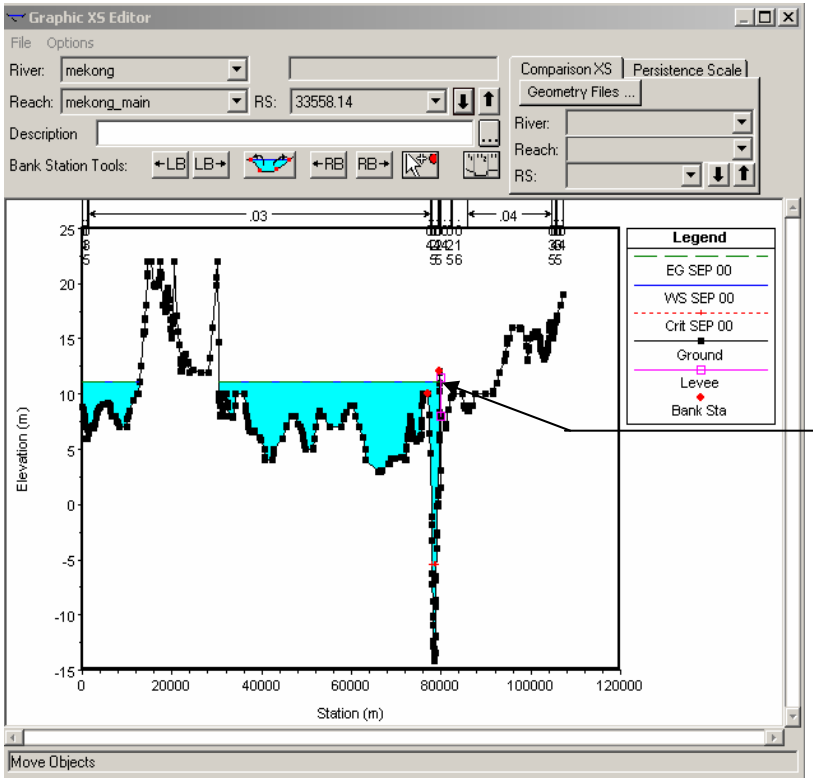
Overflowing Banks (Left)

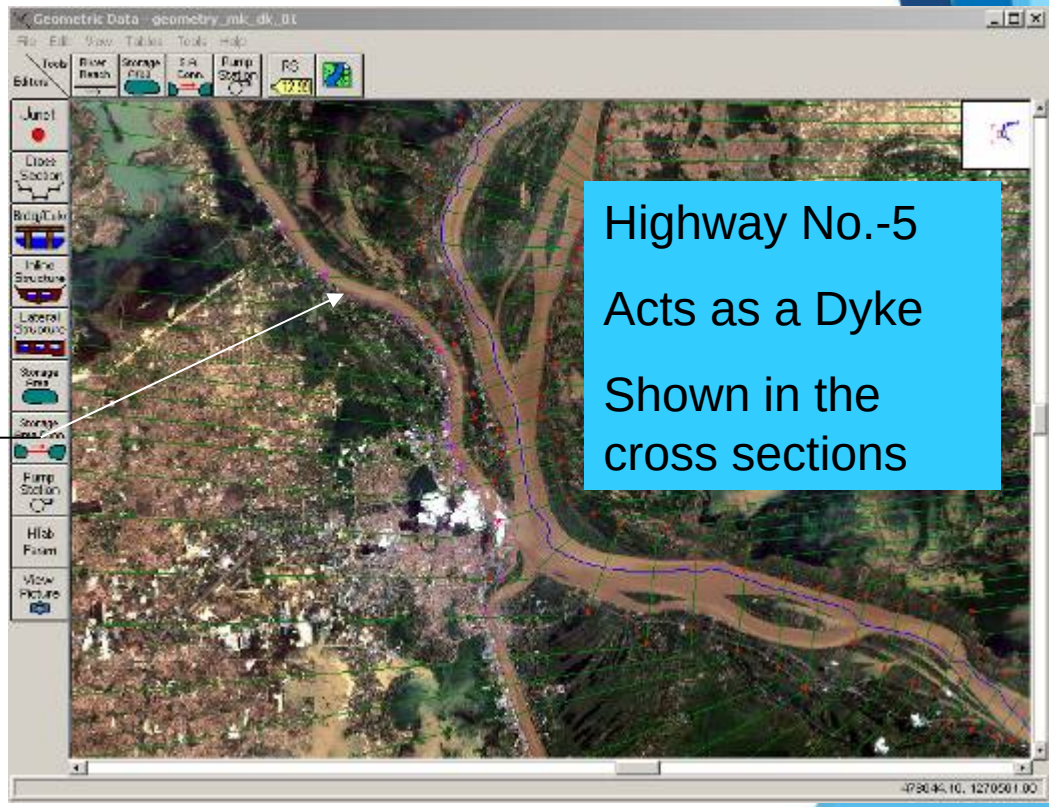


Overflowing Banks (Right)

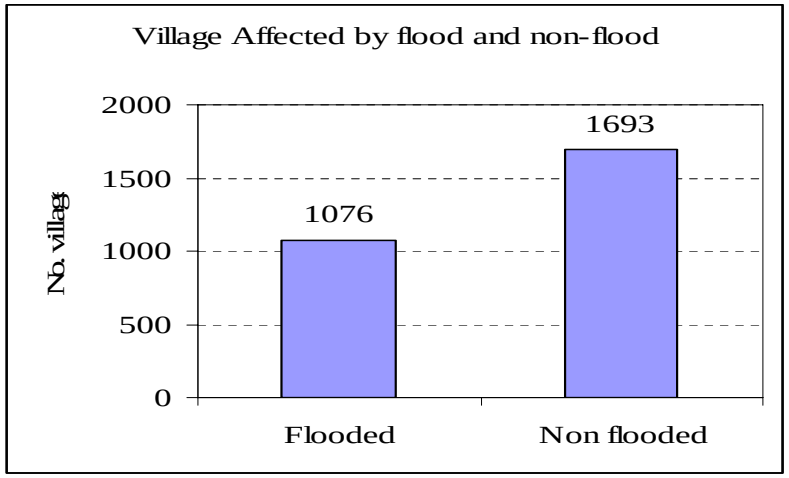


Capital Phnom Penh Was Not Flooded

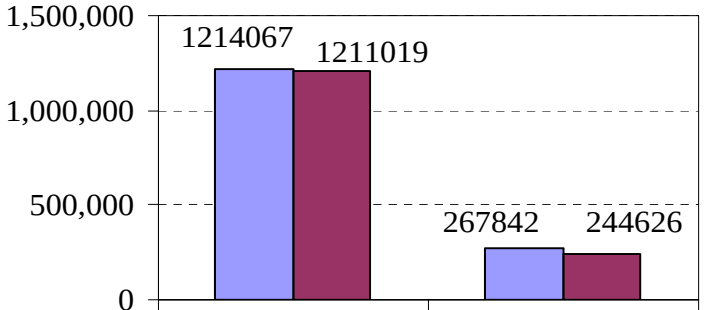




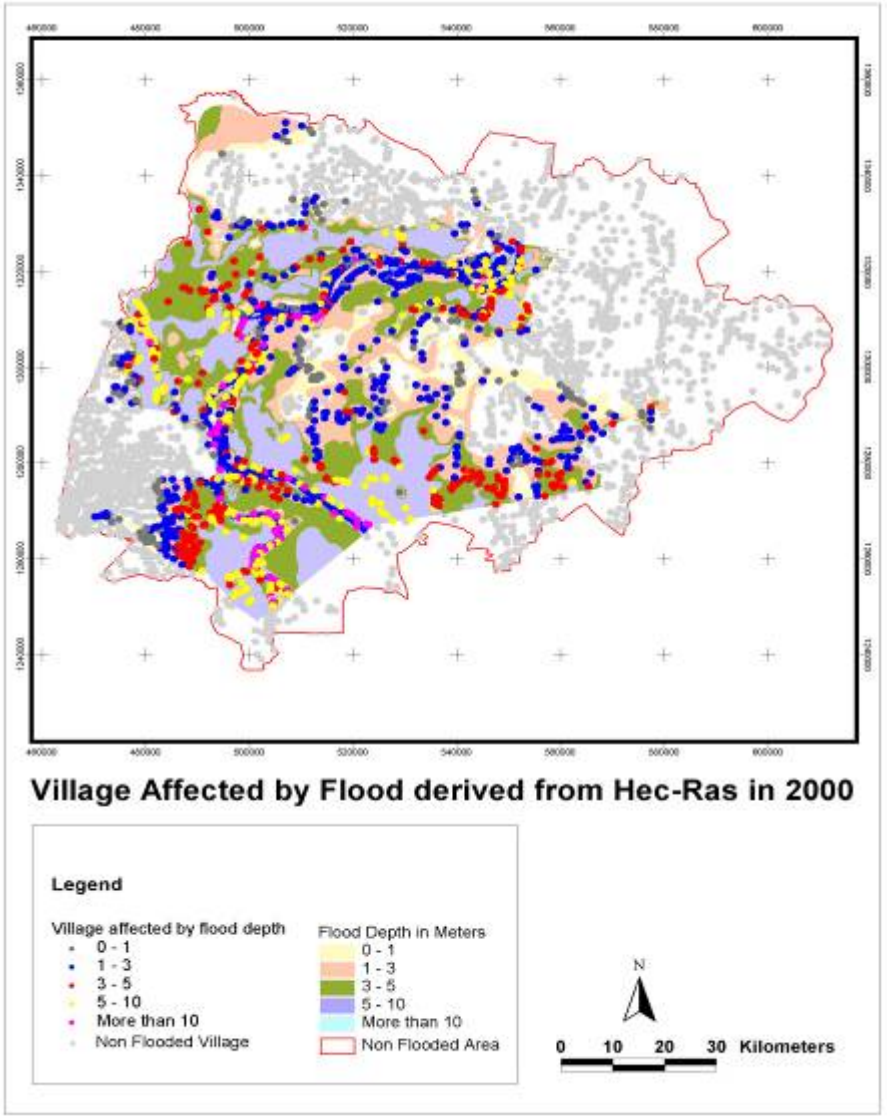
Flood Affected Villages



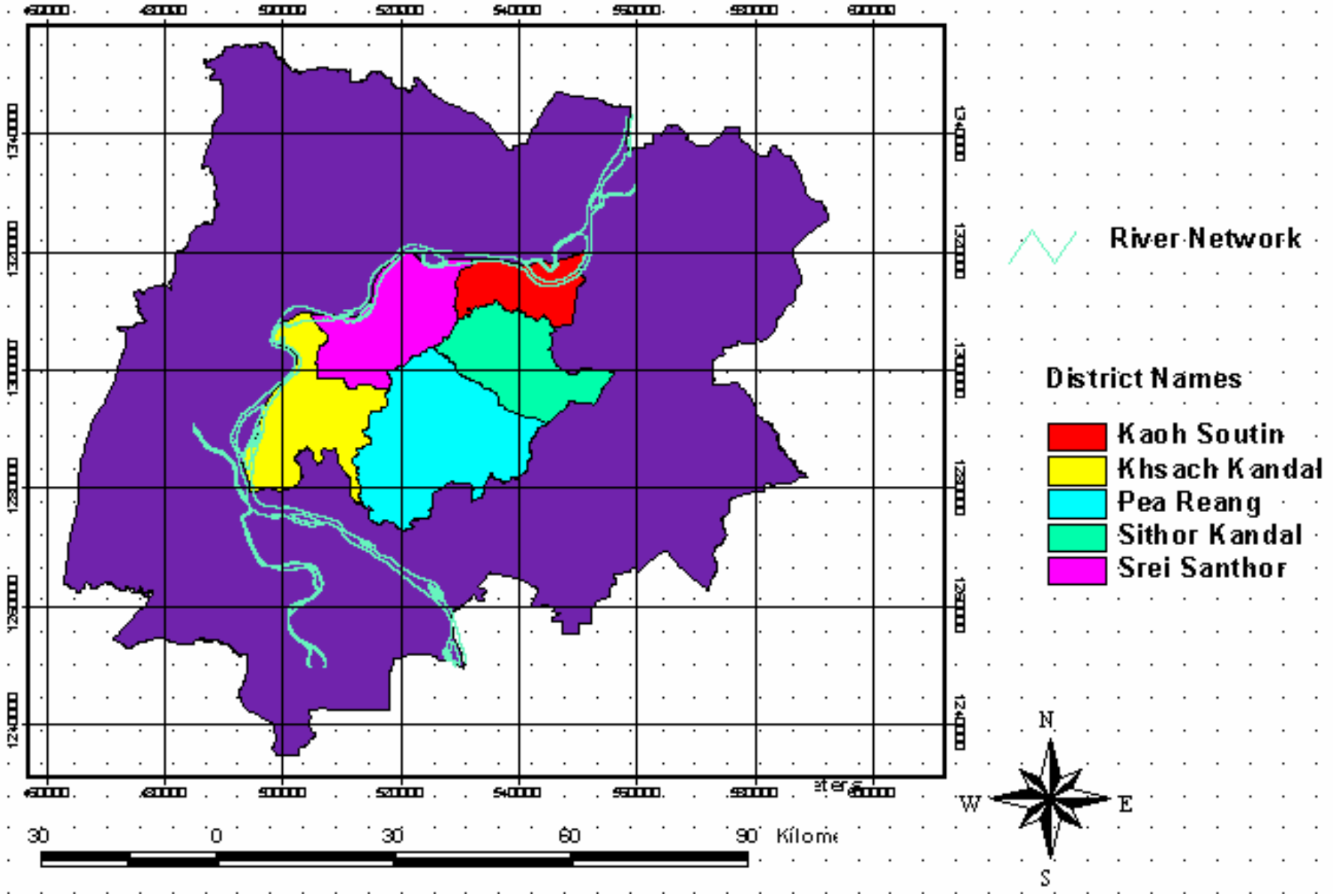
Population and household affected and no affected



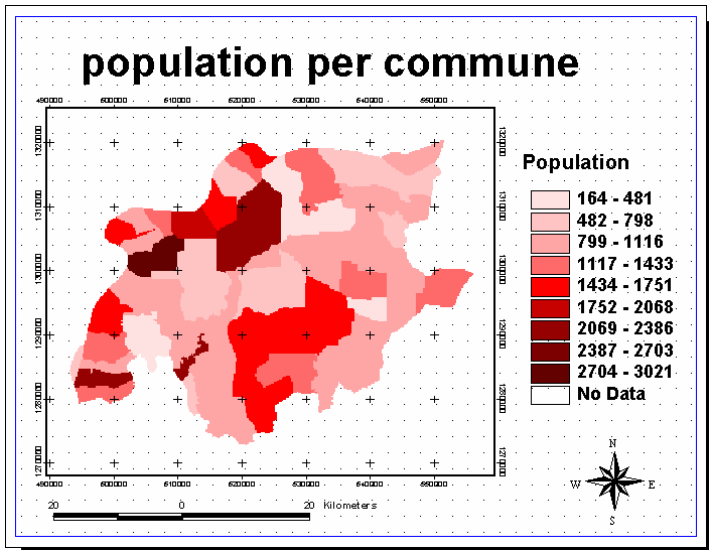
	Total Both Sexes	Total Households
flooded	1214067	267842
non-flooded	1211019	244626



Area For Hazard Analysis



Weighted Population Map



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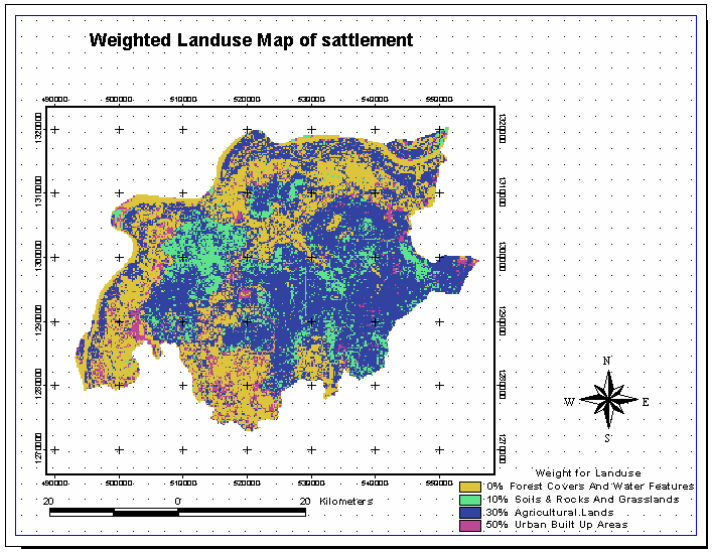
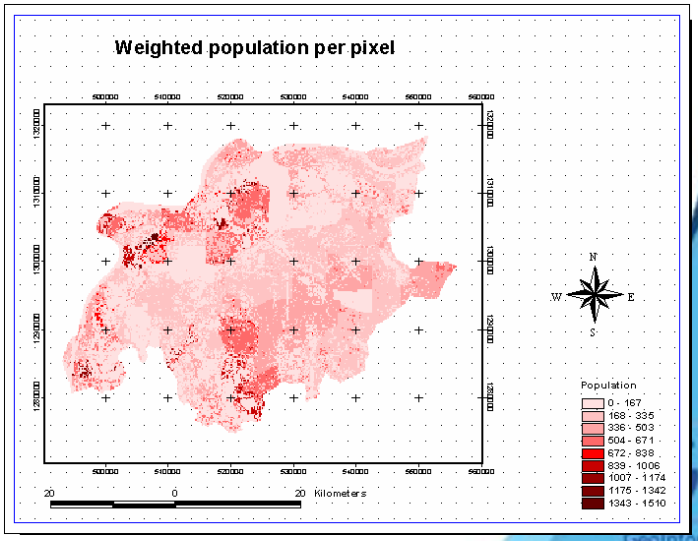


Population per commune X Weighted Landuse

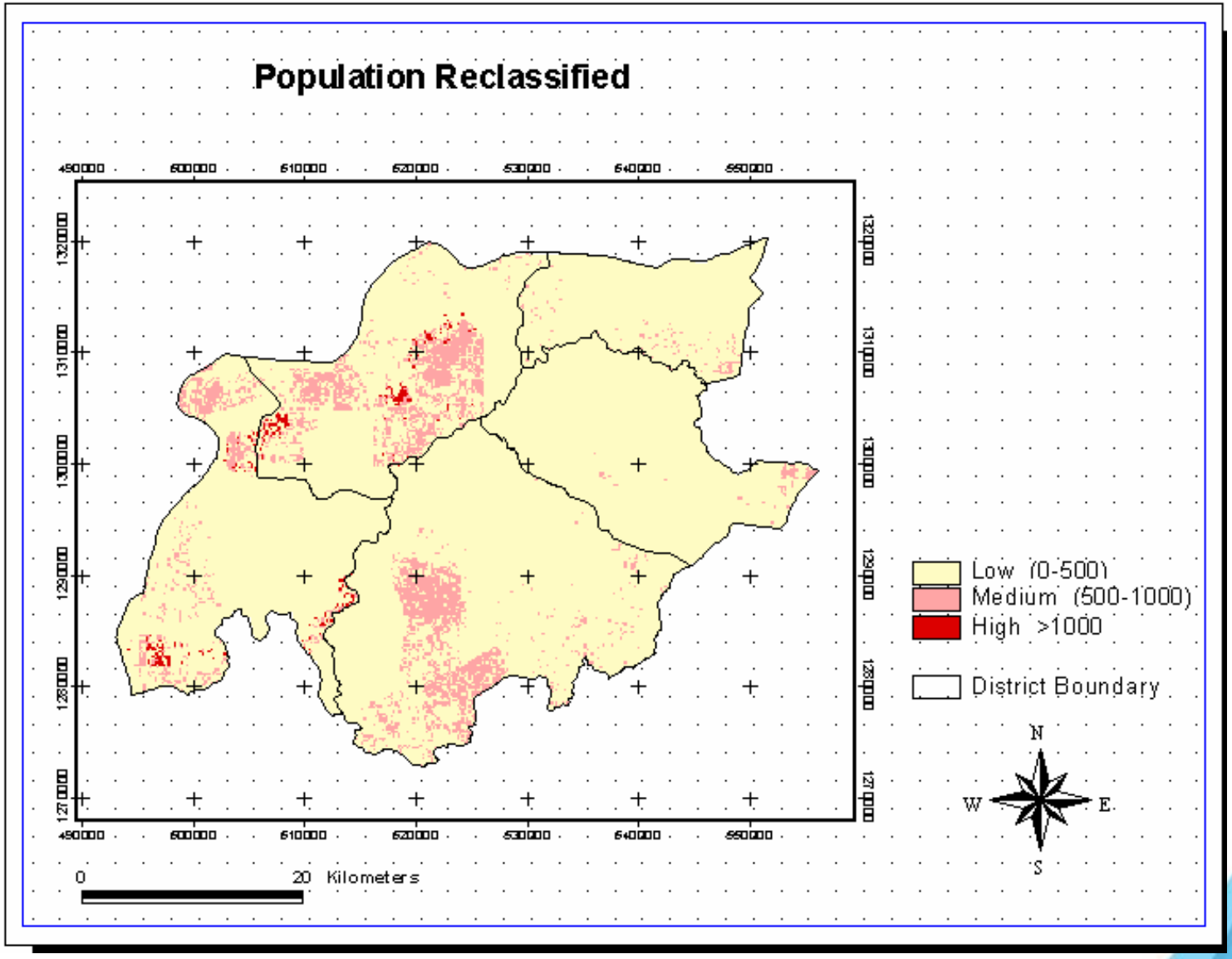
Total Weight

=

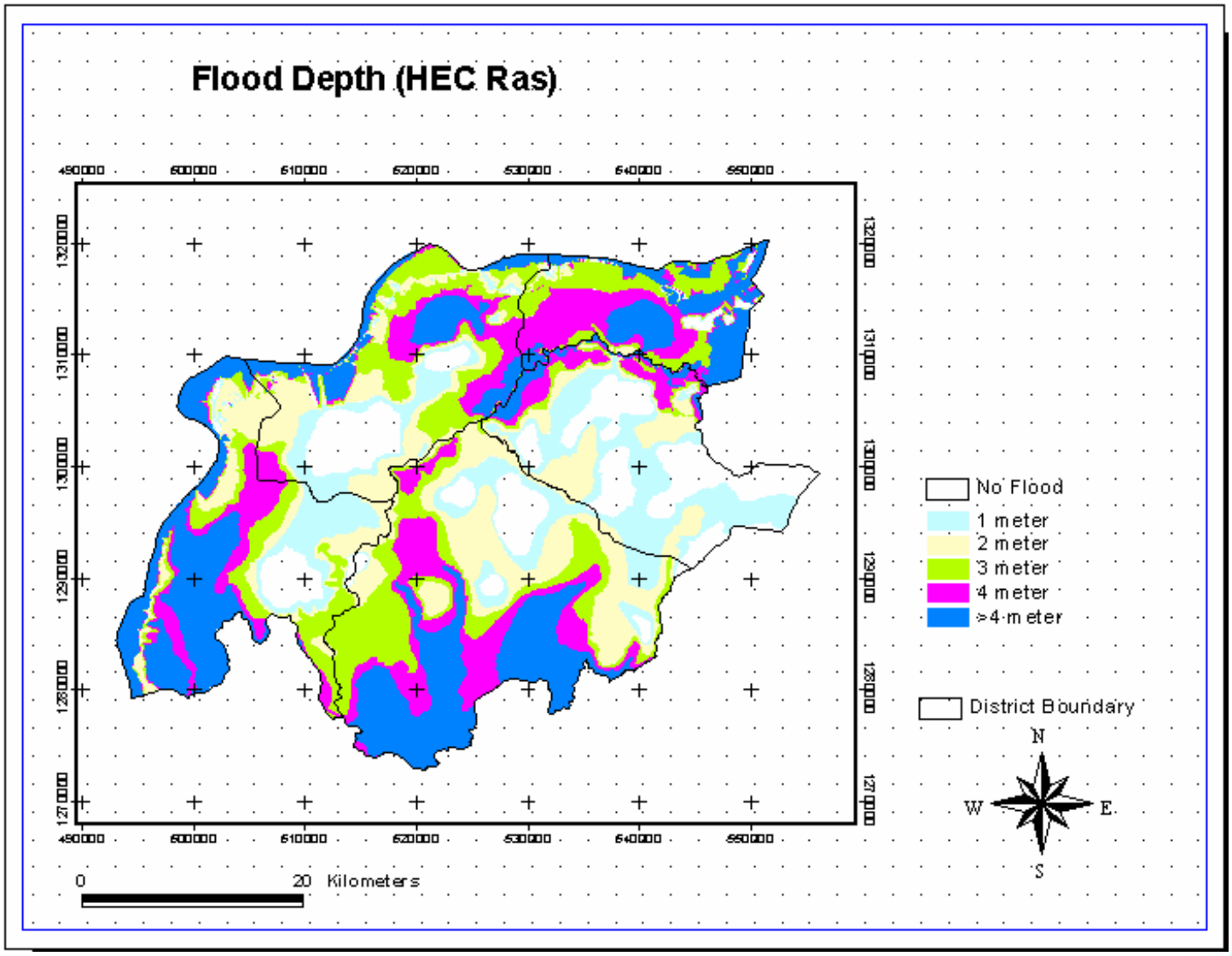


Weighted Population per pixel

Enlarged Weighted Population Map



Flood Depth From HEC-RAS Model



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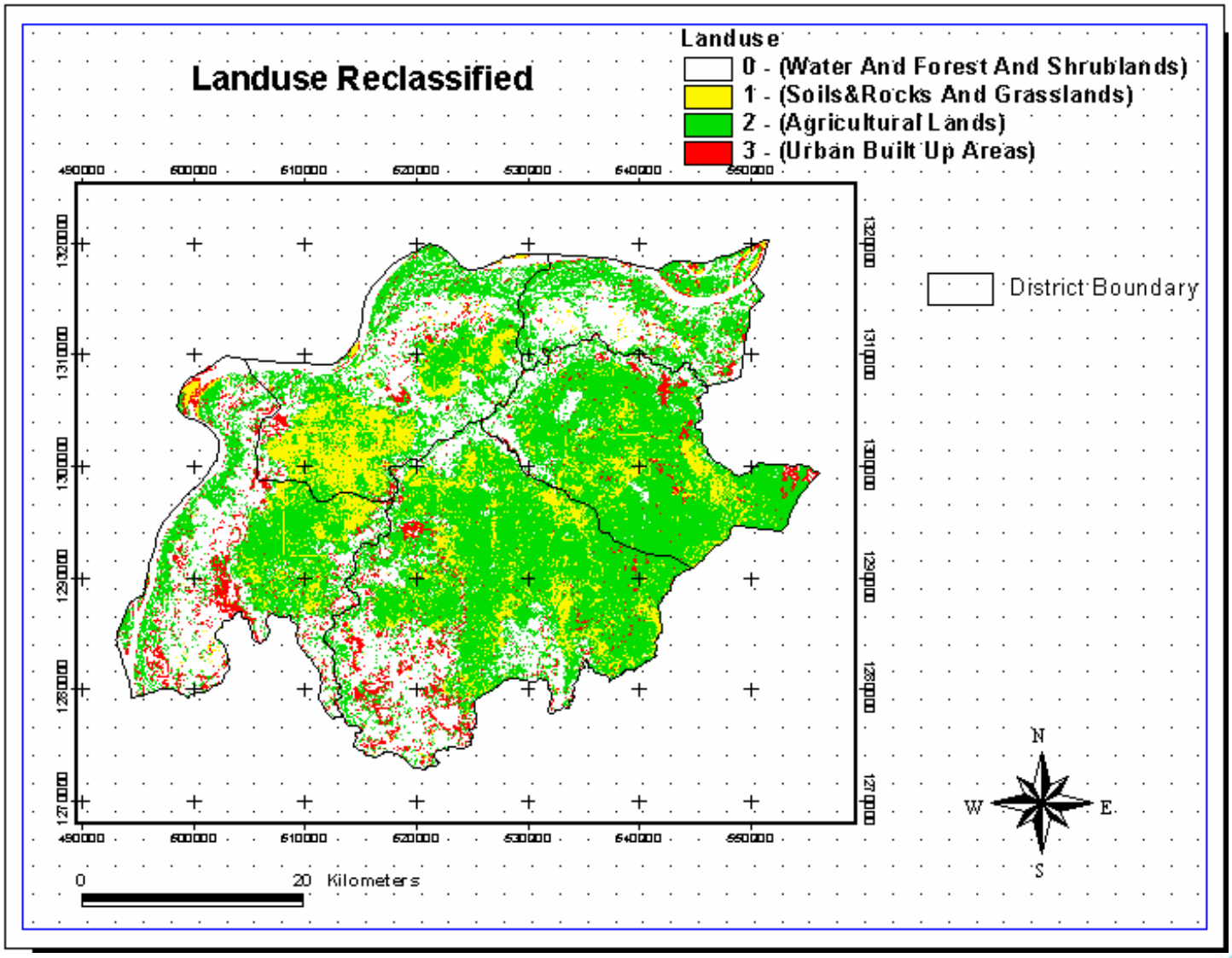
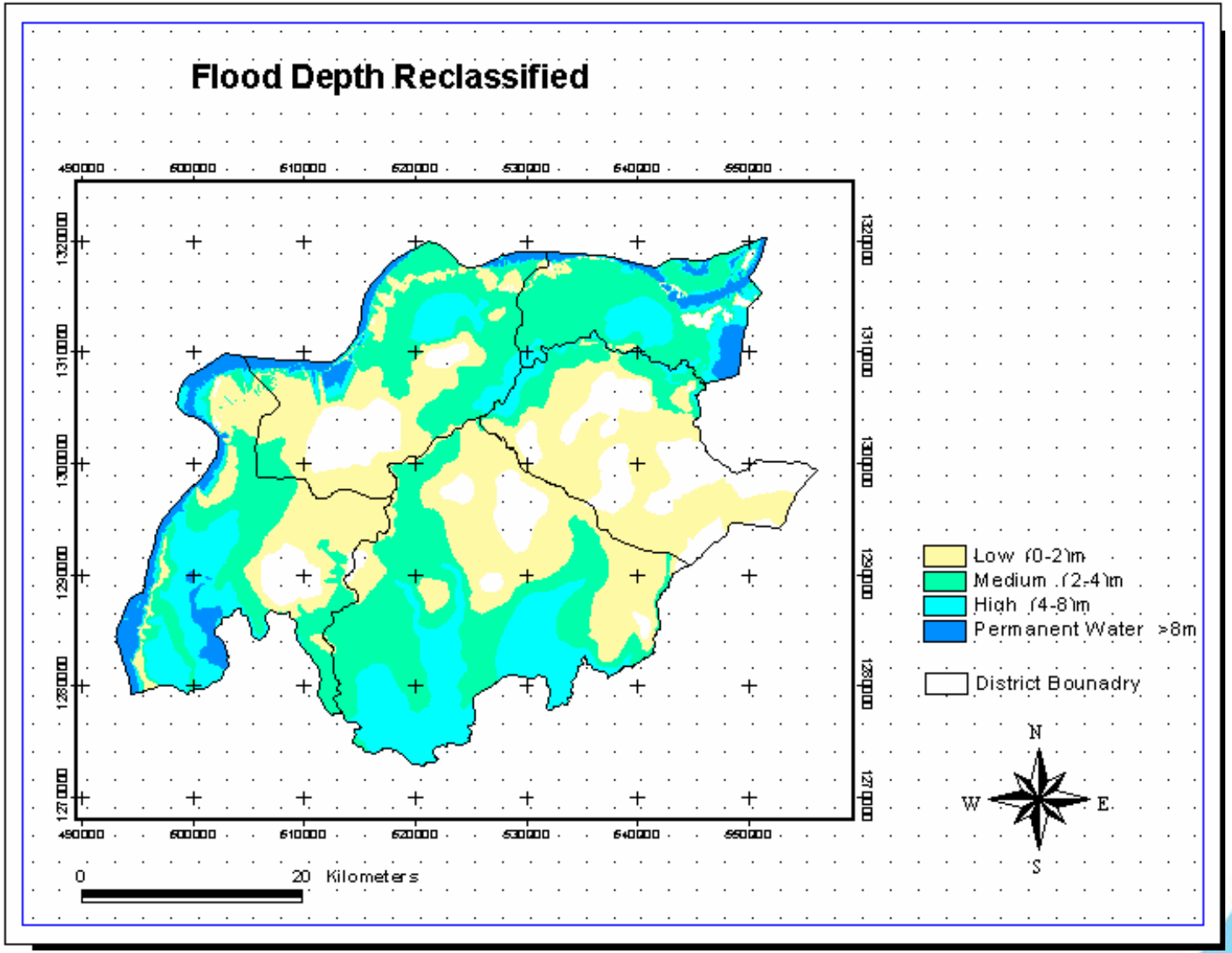
Reclassified Landuse Map



Flood Depth Map



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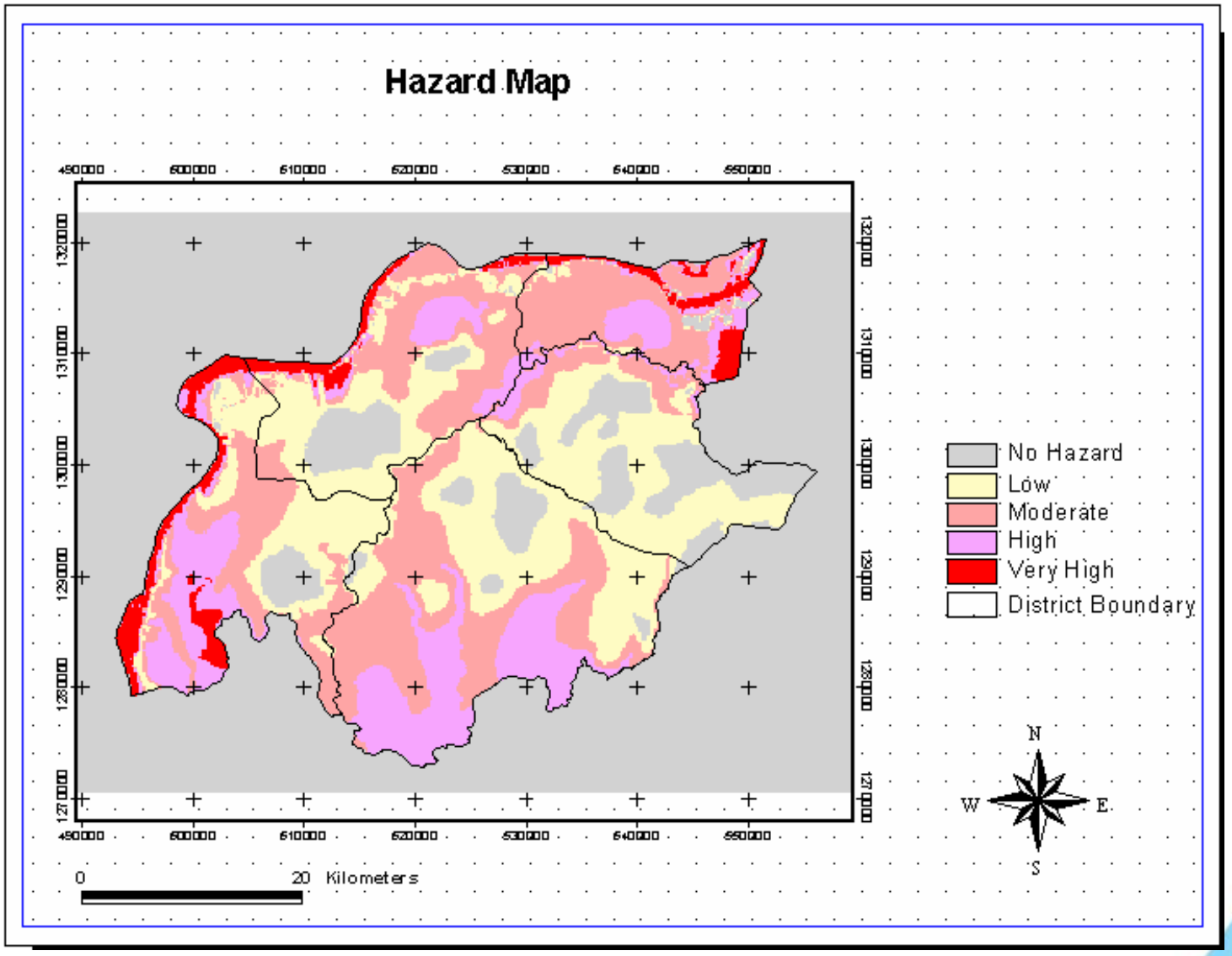
Final Hazard Map



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Summary for Cambodia

Hazard Rank	Land Affected, ha		% of total land		Population affected (10^3)	% of total population
	Agriculture	Build Up	Agriculture	Build Up		
Low	305	396	0.09	0.65	104	4.31
Medium	2387	3400	0.70	6.62	394	16.25
High/V.High	12646	12734	3.70	21.03	720	29.71

- The Extent of the flood depth from HEC-RAS is comparable with the flood map derived from RADRASAT data
- The water depth in the river from the model is comparable with the recorded water depth at the two locations at Kampong Cham and Chroy Changvar.
- The flood depth from the model is comparable with the observed depth in the flood plain.

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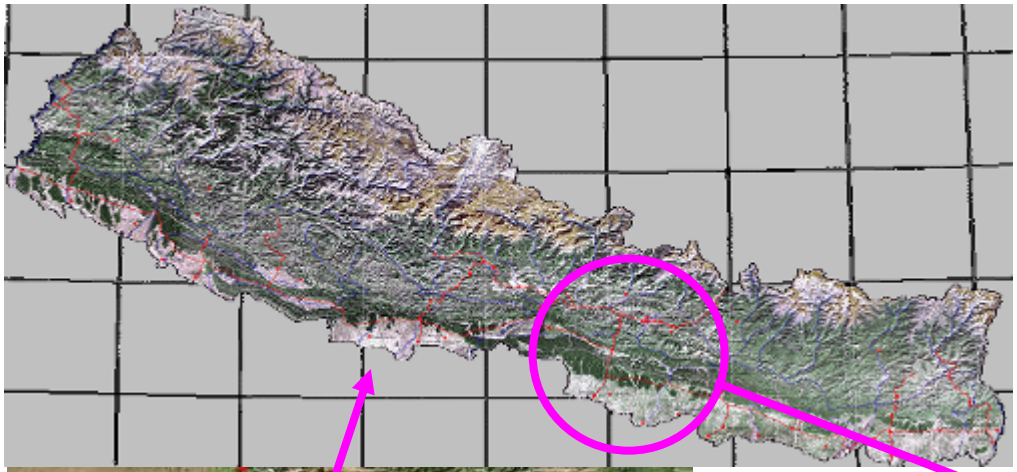
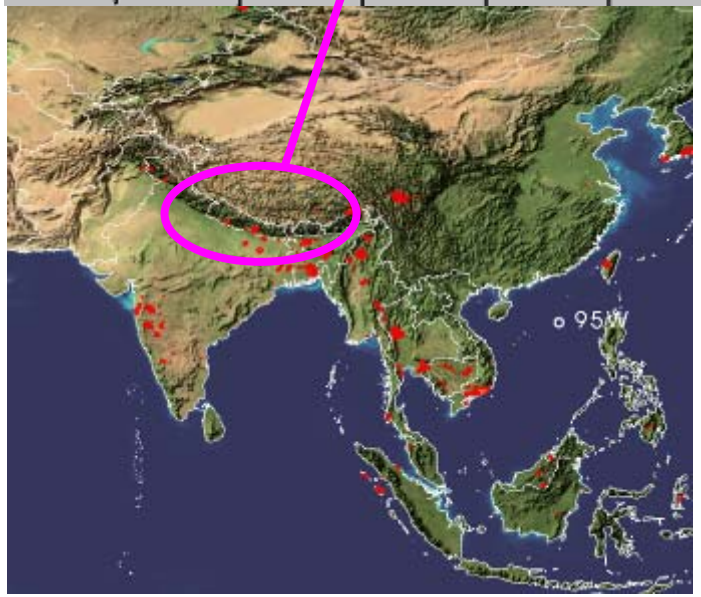
Nepal: Flood forecasting and early warning system in Bagmati flood plain





26°30'-28°00' N,
85°30'-86 ° 00' E

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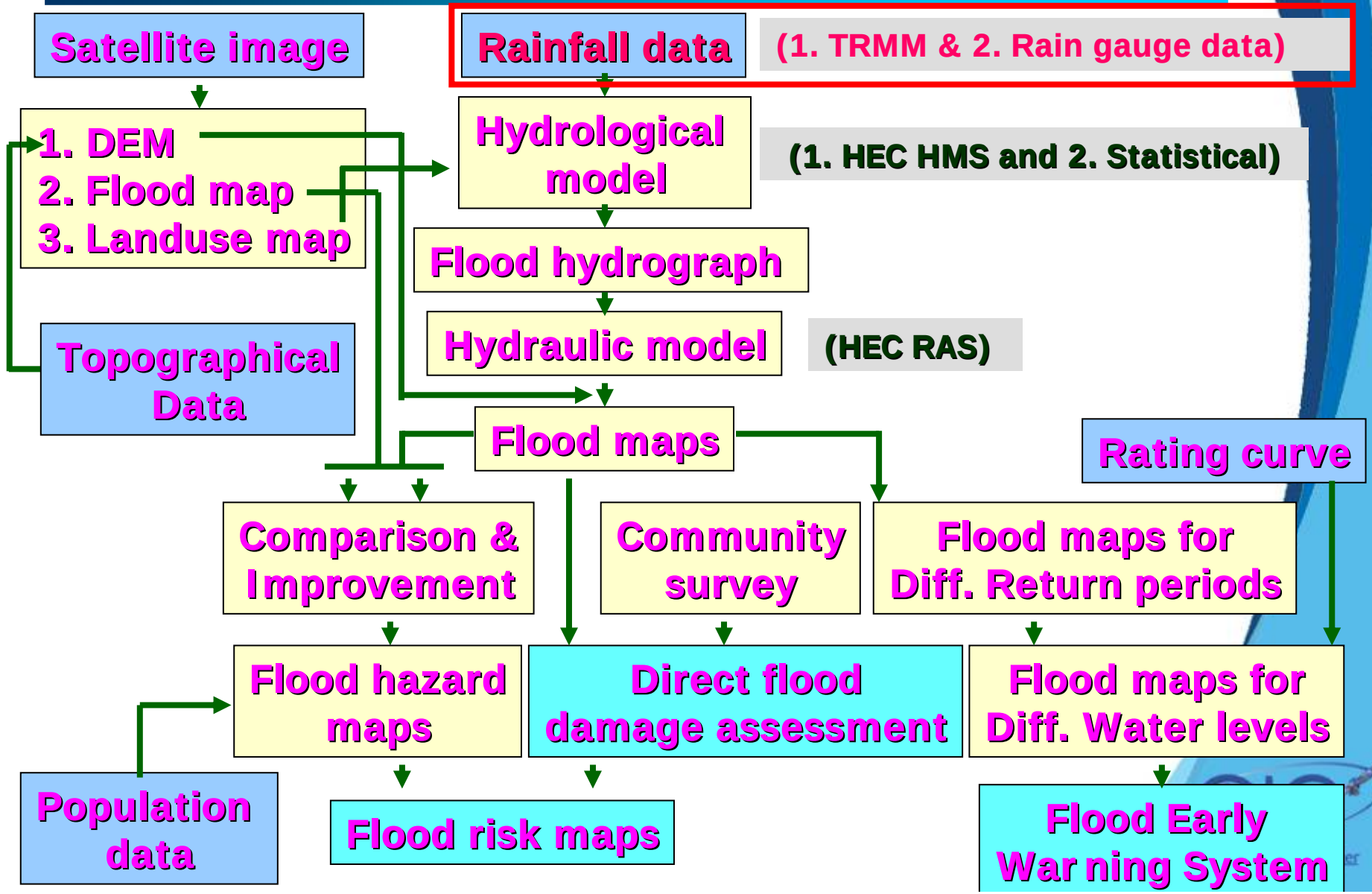
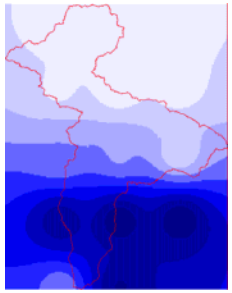
Methodology

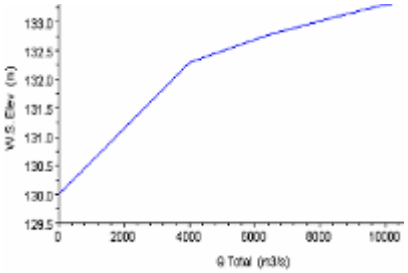


Data Available

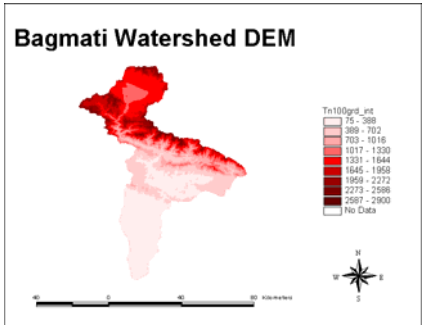
- **Satellite imagery**
  - Aster
  - Landsat

- **Hydrological data**
  - Rainfall data
  - Discharge data





- **Vector data**
  - Topographic data
  - DEM
  - Landuse data



- **Ancillary data**
  - Socio-economic data
  - Census data

Attributes of Attributes of Fvisit.shp

Shape	Shape	S_no	Place	X	Y
Point	Point	1	Garuda Chowk	630900	2982300
Point	Point	2	Jhanj Gaur Xing	631110	2968200
Point	Point	3	Bahawa bridge Gaur	627700	2961700
Point	Point	4	Chhataul	638990	2974400
Point	Point	5	Rajawada ground	633375	2973800
Point	Point	6	Gaur Camp	626700	2961700
Point	Point	7	Birta (end of flooded	629000	2988500
Point	Point	8	Brahmapuri	631240	2961890
Point	Point	9	NEC-Chapaur Road Xing	628300	2968000
Point	Point	10	Madanpur	637500	2981470
Point	Point	11	Barahathwa	646700	2987605

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Regression Analysis Approach of Peak Discharge Prediction

Assumption and Steps for discharge prediction

- TRMM rainfall data is used
- Time of Concentration = max. 24 hours
- Partially or fully covered 3B42RT grids = 15
- Contributing Grids at Gauging Station = 11

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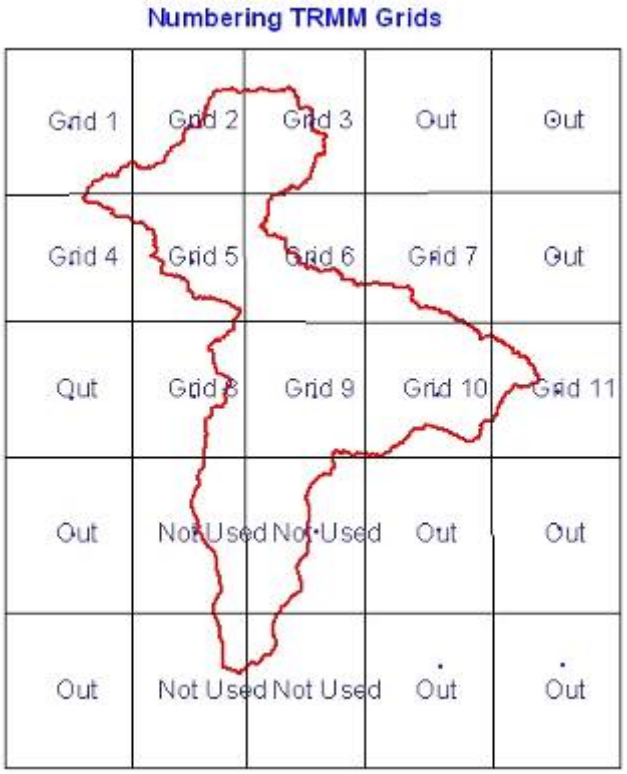
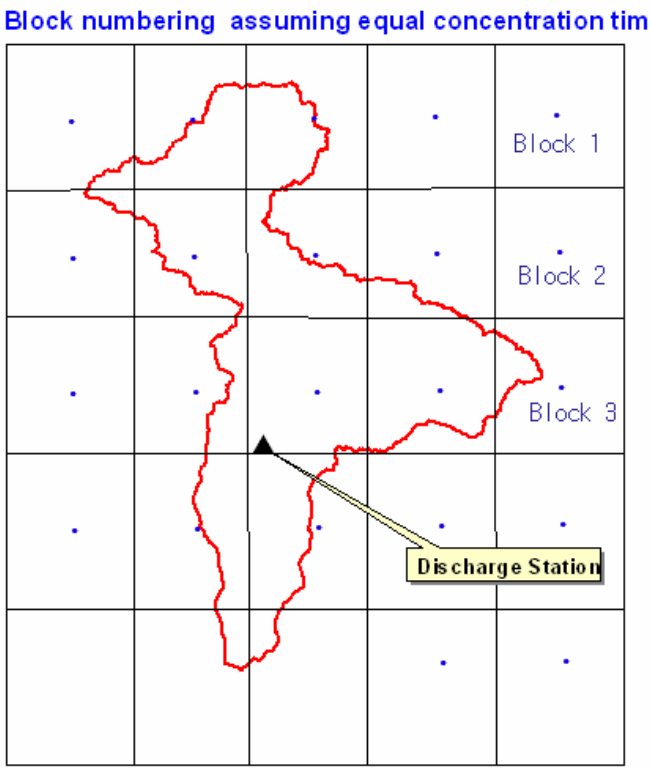
TRMM Grids in the Study Area





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Regression Analysis Approach of Extreme Discharge Prediction (Contd.)

- Grid rainfall data are weighted according to their aerial coverage
- Grids having equal time of concentration are grouped together (called Block)
- Discharge (Q) = f (weighted time series of 3-hourly rainfall)

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Regression Analysis Approach of Extreme Discharge Prediction (Contd.)

Test Datasets

- TRMM 3-hourly rainfall data covering June to September 2004
- Daily discharge data of the same period (Dependent Variable)

Validation Data

- 2005 Monsoon (June to September)
- Predicted Variable is daily discharge data of Monsoon 2005

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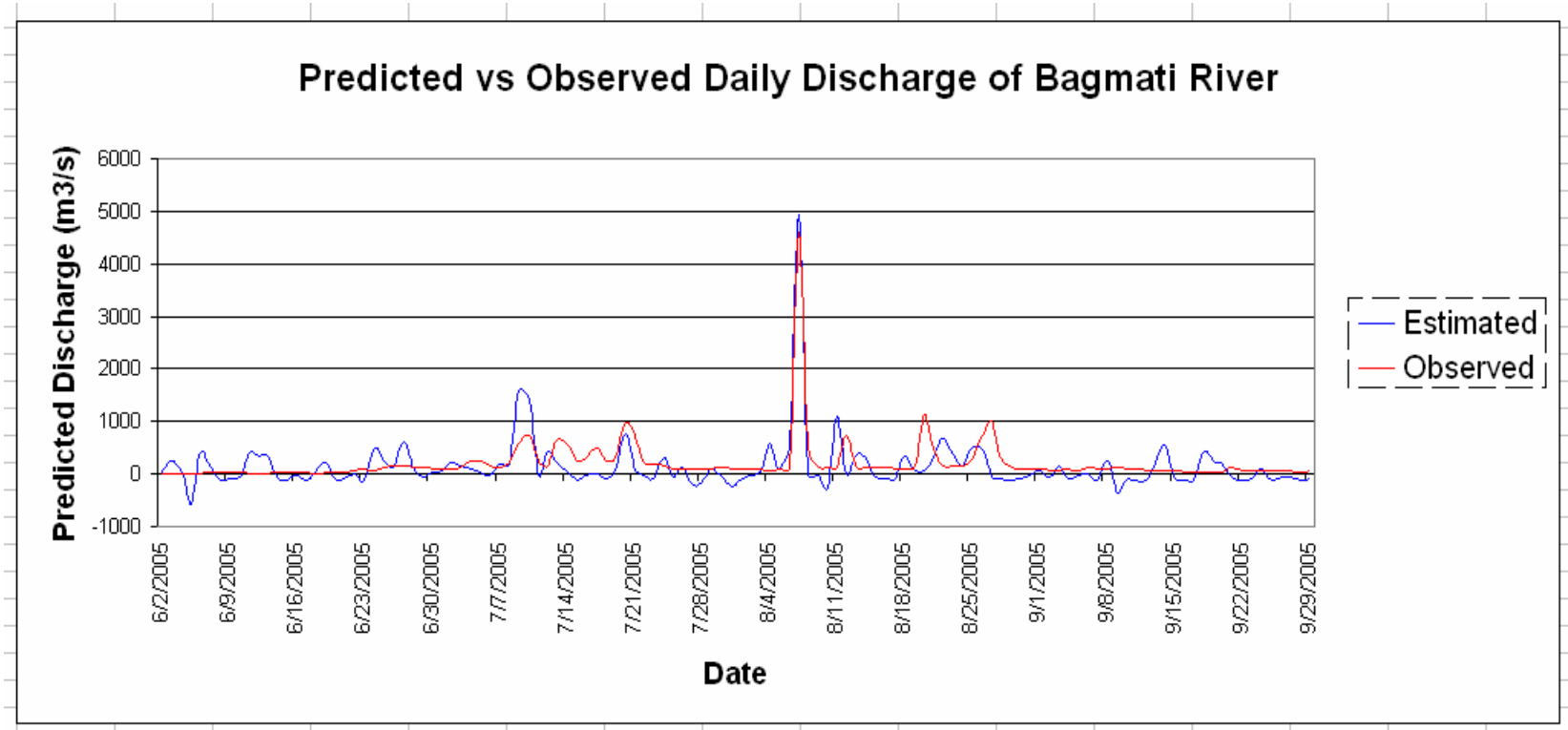
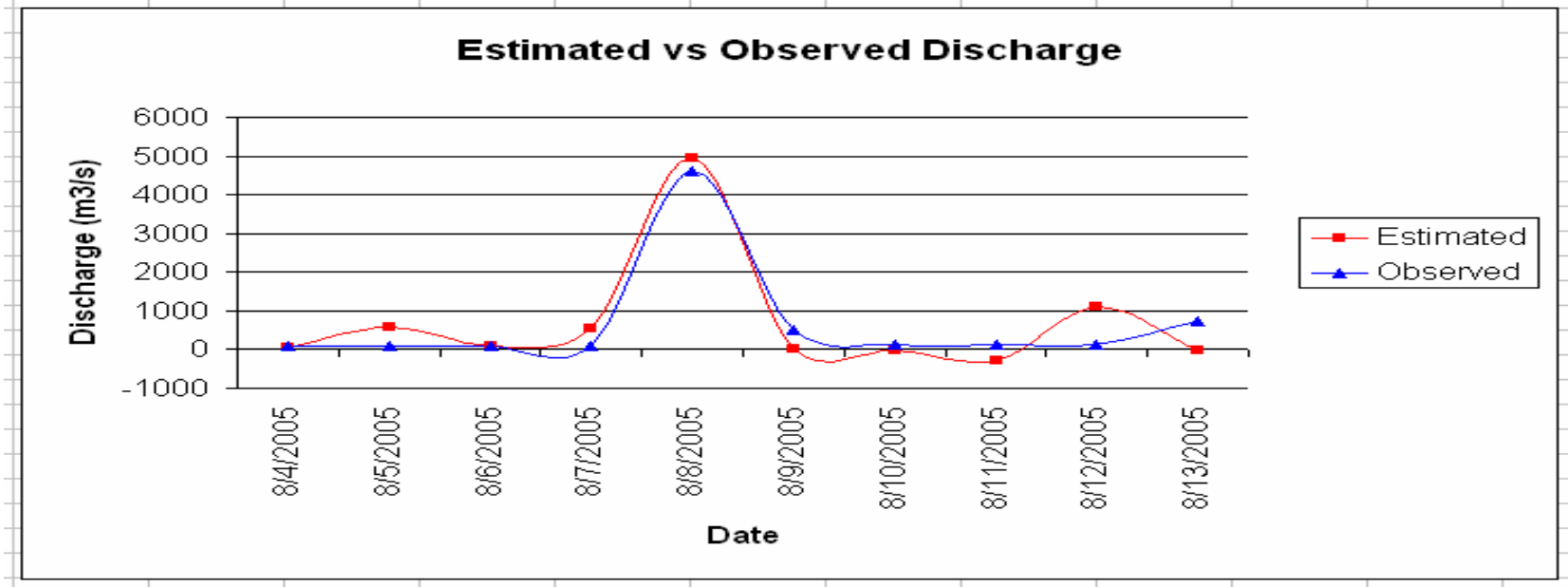

Predicted vs Observed Daily Discharge of Bagmati River
Predicted Discharge (m3/s)
6000
5000
4000
3000
2000
1000
0
-1000
6/2/2005
6/9/2005
6/16/2005
6/23/2005
6/30/2005
7/7/2005
7/14/2005
7/21/2005
7/28/2005
8/4/2005
8/11/2005
8/18/2005
8/25/2005
9/1/2005
9/8/2005
9/15/2005
9/22/2005
9/29/2005
Date
Estimated
Observed


Estimated vs Observed Discharge
Discharge (m3/s)
6000
5000
4000
3000
2000
1000
0
-1000
8/4/2005
8/5/2005
8/6/2005
8/7/2005
8/8/2005
8/9/2005
8/10/2005
8/11/2005
8/12/2005
8/13/2005
Date
Estimated
Observed

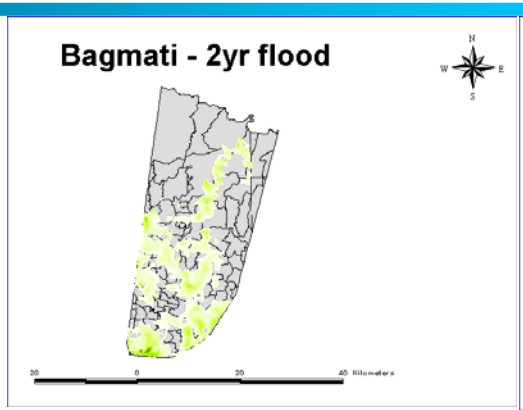
Flood maps

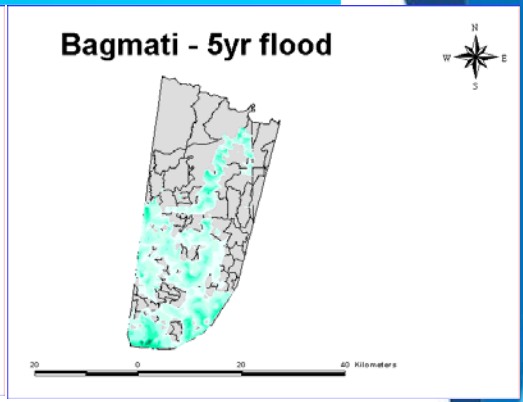
Input Discharge

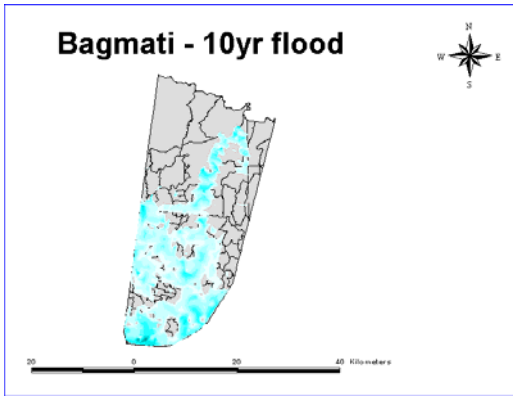
Return Period	Discharge
2 year	**3750**
5 year	**6150**
10 year	**7750**
20 year	**9250**
50 year	**11250**
100 year	**12700**

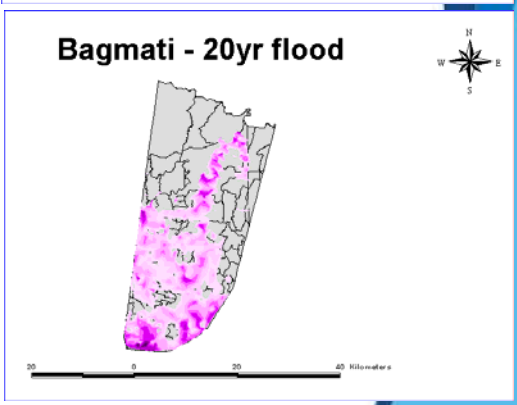
Inundated area

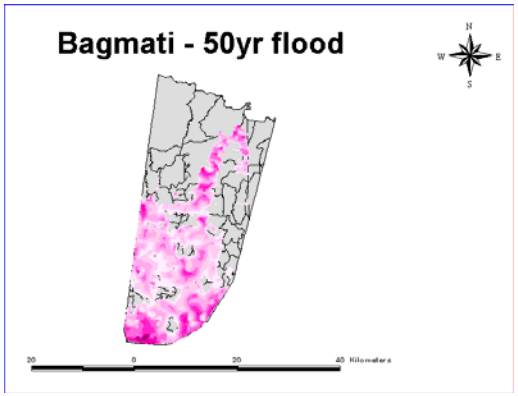
Return period	Area inundated	% area inundated
2 year	**363.4**	**36.9**
5 year	**403.9**	**41**
10 year	**422.9**	**42.9**
20 year	**437.7**	**44.5**
50 year	**454.8**	**46.2**
100 year	**465.6**	**47.3**

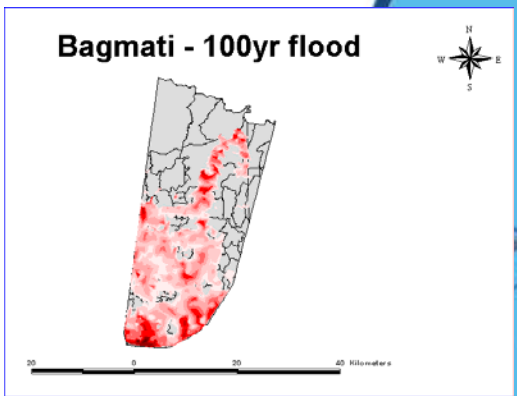












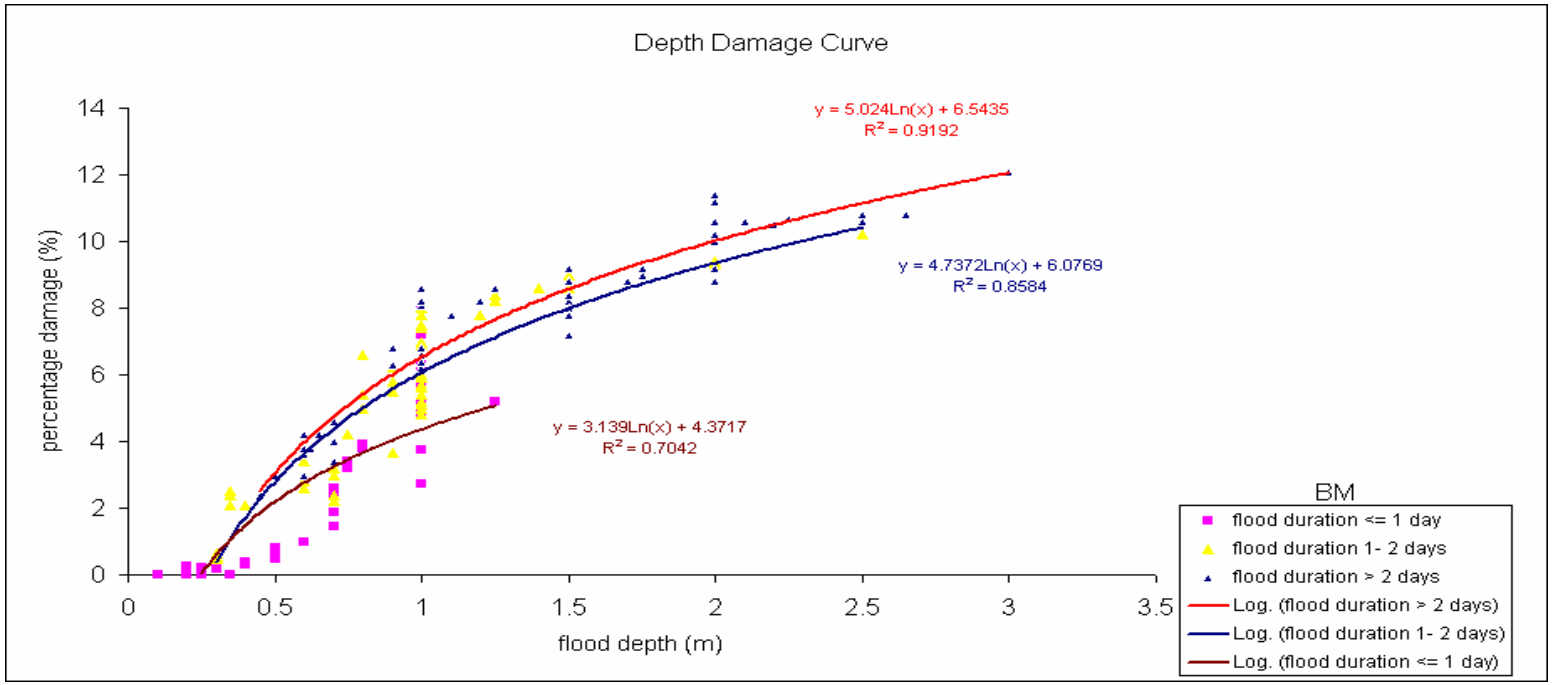
Damage function analysis - 1

Summary of Survey Data for Residential Buildings						
Building Classification	Adobe - 276 Brick Masonry - 188 RCC frame - 26					
S. No.	**Variables**	**Unit**	**Min**	**Max.**	**Mean**	**Range**
1	Building age	year	2	53	15.77	51
2	Building plinth area	sq. m	20	338.72	121.56	318.72
3	Number of stories	No.	1	3	1.11	2
4	Plinth height	m	0.1	2	0.35	1.9
5	Height of 1st Floor	m	2	3.15	2.89	1.15
6	Present replacement value of building structure	Thousands NRs.	21.53	6458	632	436.87
7	Maximum flood height	m	0.1	3	0.9563	2.9
8	Flood duration	day	0.25	7	2.024	6.75
9	Cost of damage to building structure	NRs.	500	50000	8560	49500
10	Cost of damage to building contents	NRs.	200	50000	8505	49800
11	Cost of damage to outside facilities	NRs.	100	12000	2126.5	11900

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std.	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Percentage damage of Building Structure	490	38	0	38	8.79	8.971	80.474	1.336	.110	.720	.220
Age (yrs.)	490	51	2	53	15.77	9.527	90.761	1.585	.110	3.843	.220
Plinth Height (m)	490	1.90	.10	2.00	.3549	.29033	.084	1.713	.110	3.483	.220
Flood Depth (m)	490	2.90	.10	3.00	.9563	.54924	.302	.989	.110	.607	.220
Flood Duration (days)	490	6.90	.10	7.00	2.0108	1.12229	1.260	.600	.110	.655	.220
No. of Storey	490	2	1	3	1.11	.358	.128	3.351	.110	11.333	.220
Valid N (listwise)	490										

Depth vs. Damage: Flood duration (B.M)



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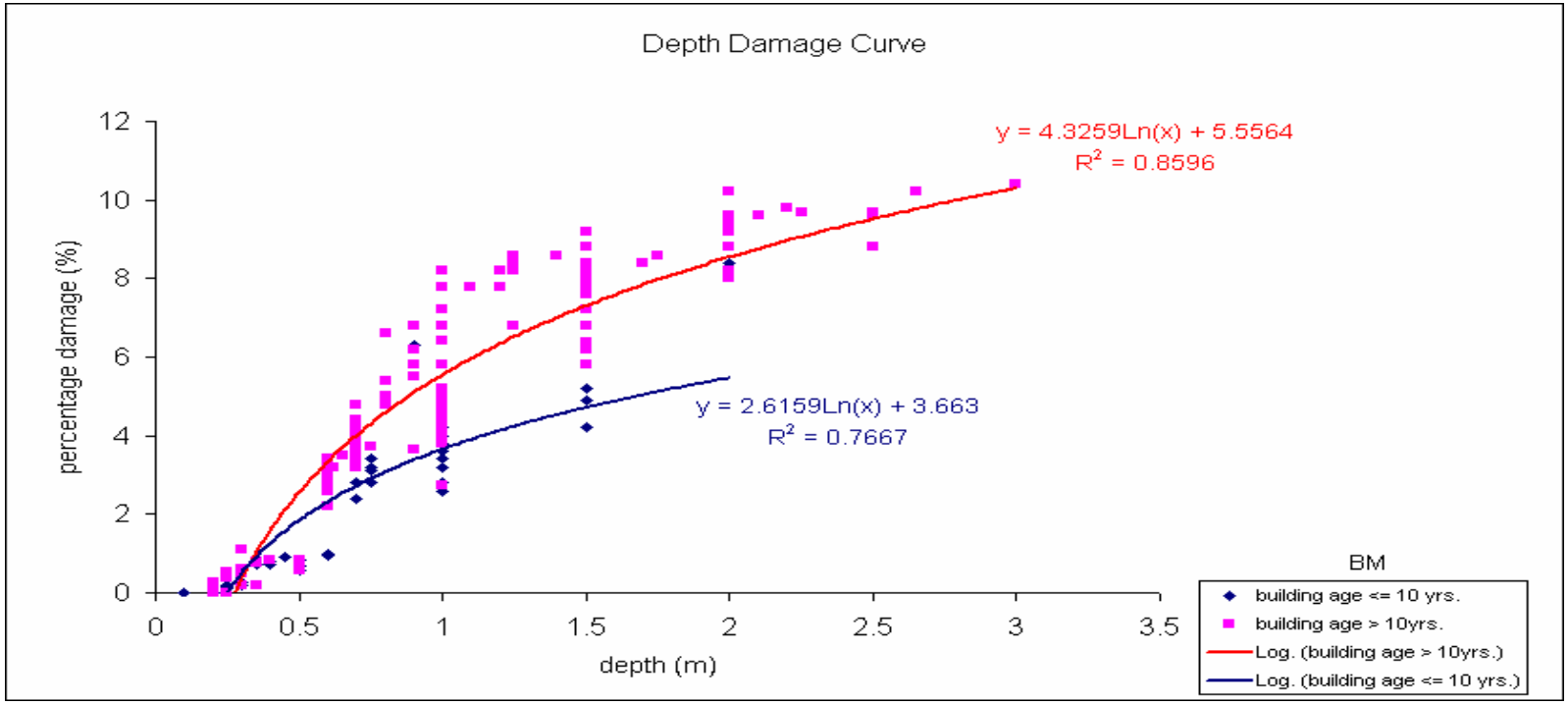
Depth vs. Damage: Building Age (B.M)



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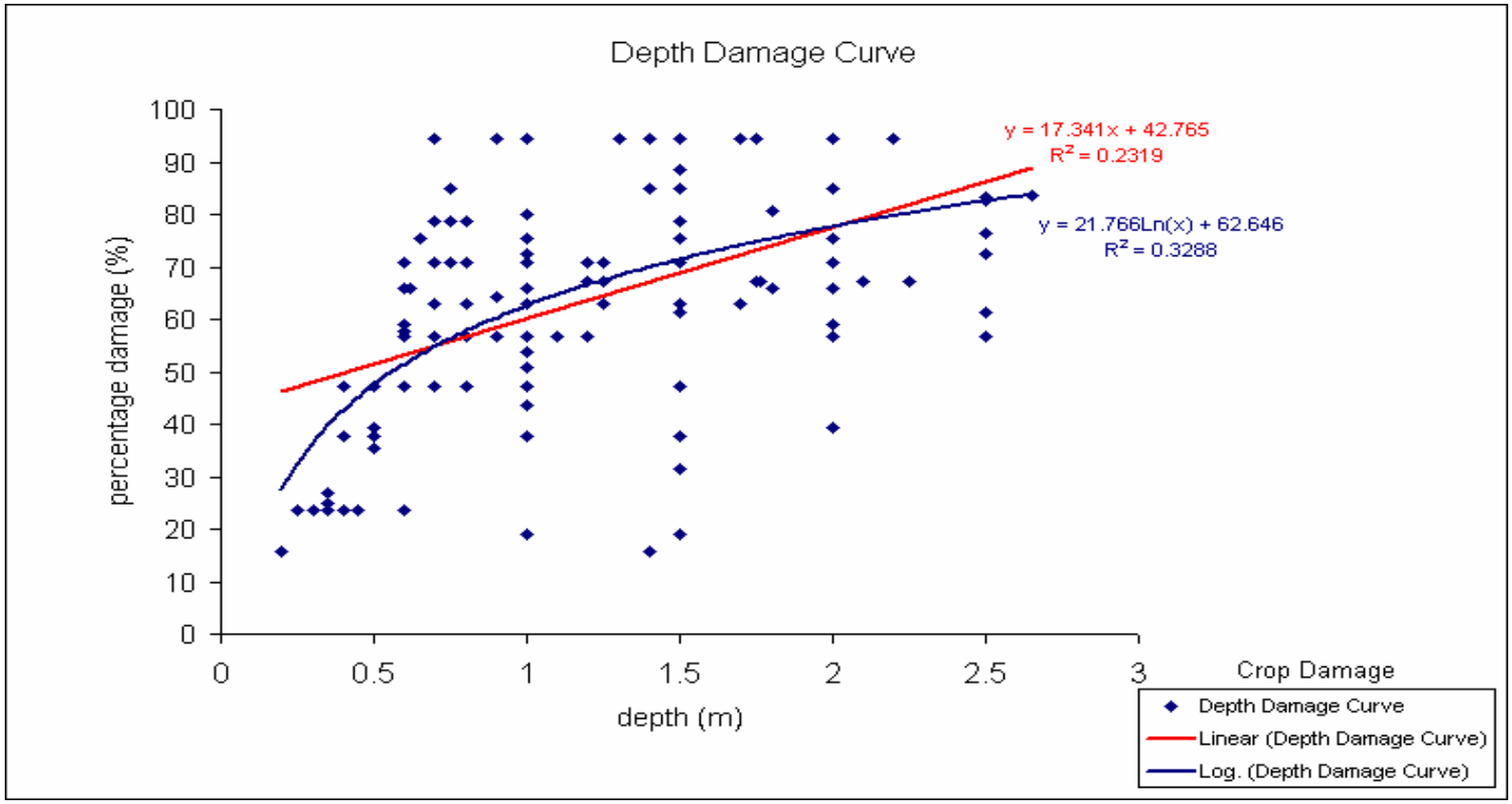
Depth vs. Damage: Crop Damage



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Summary for Nepal

- Diurnal variability of TRMM rainfall field is well captured
- TRMM rainfall field is more associated with the average rainfall field rather than a point rainfall
- Weighted time series 3-hourly TRMM data is well predict the peak discharge which can be directly used for flood forecasting.
- The flood maps prepared for six return periods of 2, 5, 10, 20, 50 & 100yrs showed inundation area ranged from 363 – 465 sq. km. (37-47% of the total area of the two districts)
- Flood loss functions were generated for structural damage of residential and commercial buildings

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Acknowledgements

Cambodia

1. Yin Savuth	Ministry of Water Resources and Meteorology
2. Ro Narith	Ministry of Land Management, Urban, Planning and Construction
3. Noun Kunthea	RFMMC, Mekong River Commission

Nepal

Sudarshan Karki	Survey Department
Rishi Ram Sharma	Dept of Hydro. and Met.
Rajan Shrestha	Dept of Water Induced Disaster Prevention

Geoinformatics Center/AIT

Mr. Tanka Kafle


Thank you for your kind attention