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Climate Change and Anthropogenic Impacts Assessment on the Flood Hazard in the Batanghari River basin, Sumatera, Indonesia

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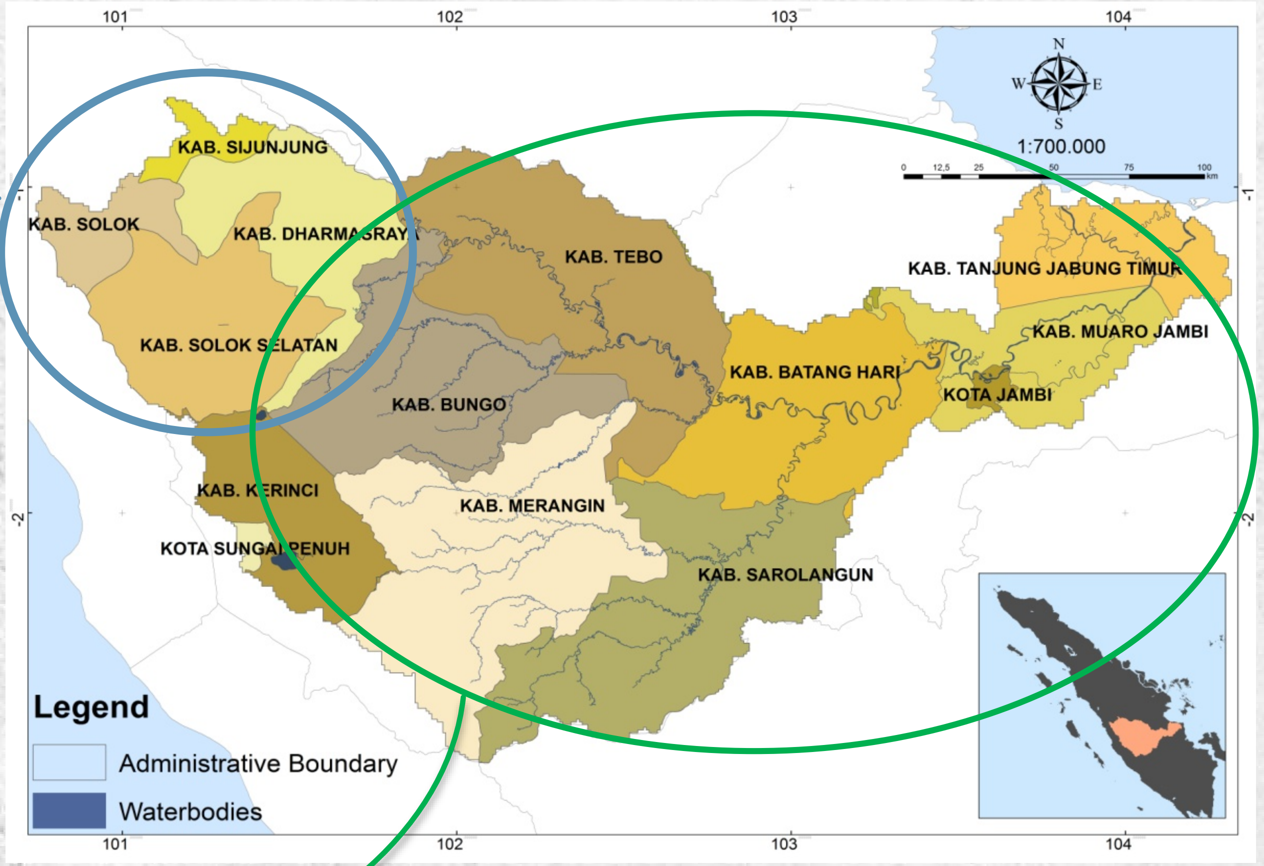
JASTIP-Net Workshop on Indonesian Proposals for Disaster Prevention (WP4)
Date: 3rd November 2017, 13:15 – 17:30, Salak Tower Hotel

STUDY AREA

West Sumatera Province



Study area consists of 14 district

Jambi Province

BATANGHARI RIVER BASIN

- Approximate total area is 47.479,54 km^2
- Landuse type dominated by plantated area (e.g., oil palm and rubber)
- Almost every year many areas were flooded
- Biggest flood occured in 2003

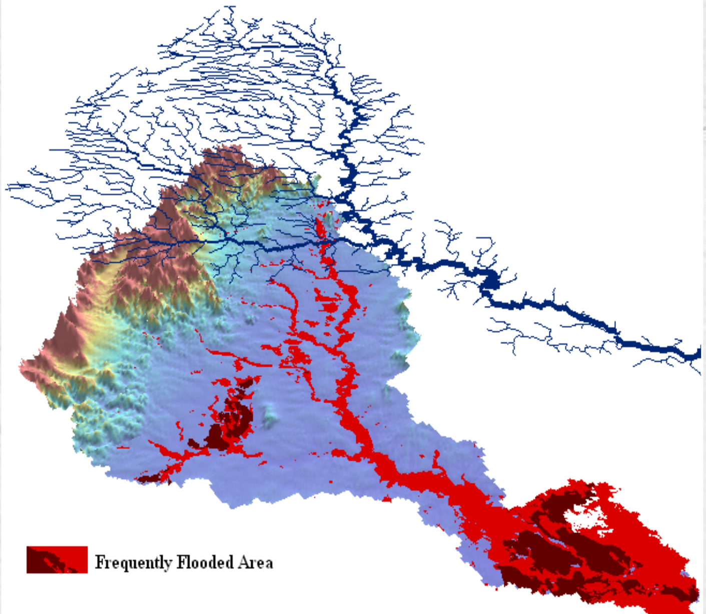


Figure 1. Batanghari River basin boundary and its river networks.

I INTRODUCTION

FLOOD RISK AT BASIN & MICRO SCALE

Local Agency for Disaster Management (BPBD) of Jambi Province
Local Agency for River Basin Management (BPDAS) of Jambi Province

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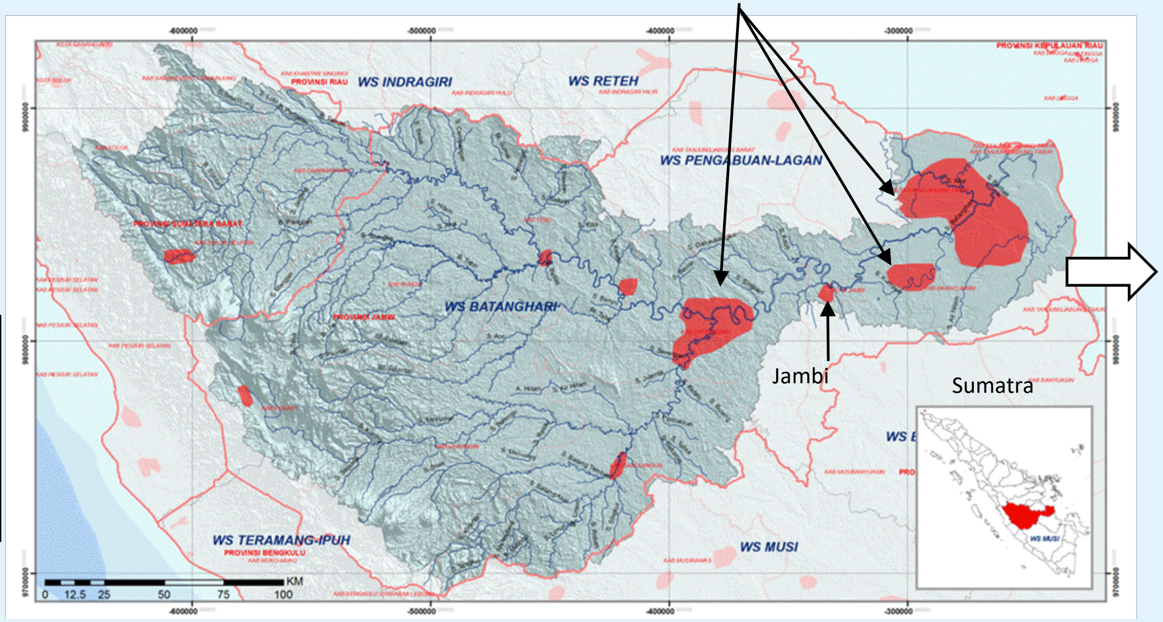
Requested to make Quantitave Flood Risk Map (in Damage Cost Unit) at Basin Scale and Considering More Physical Process & Climate Change Issue in Delineating the Map

Upstream

Natural Forest



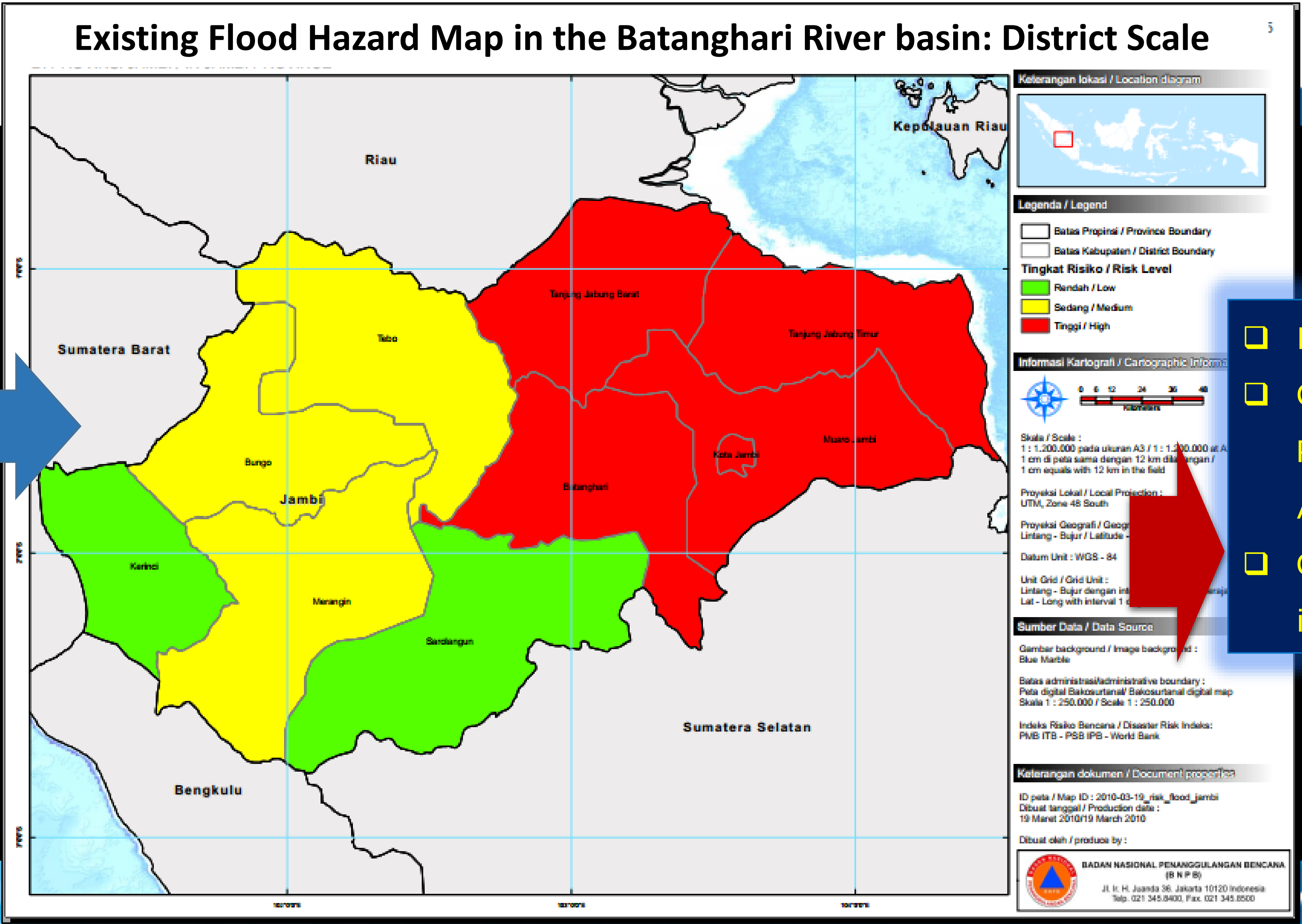
Downstream

Peatland Area

OBJECTIVE: To produce the Map of Flood Hazard with High Resolution & considering CC and LUC

I INTRODUCTION

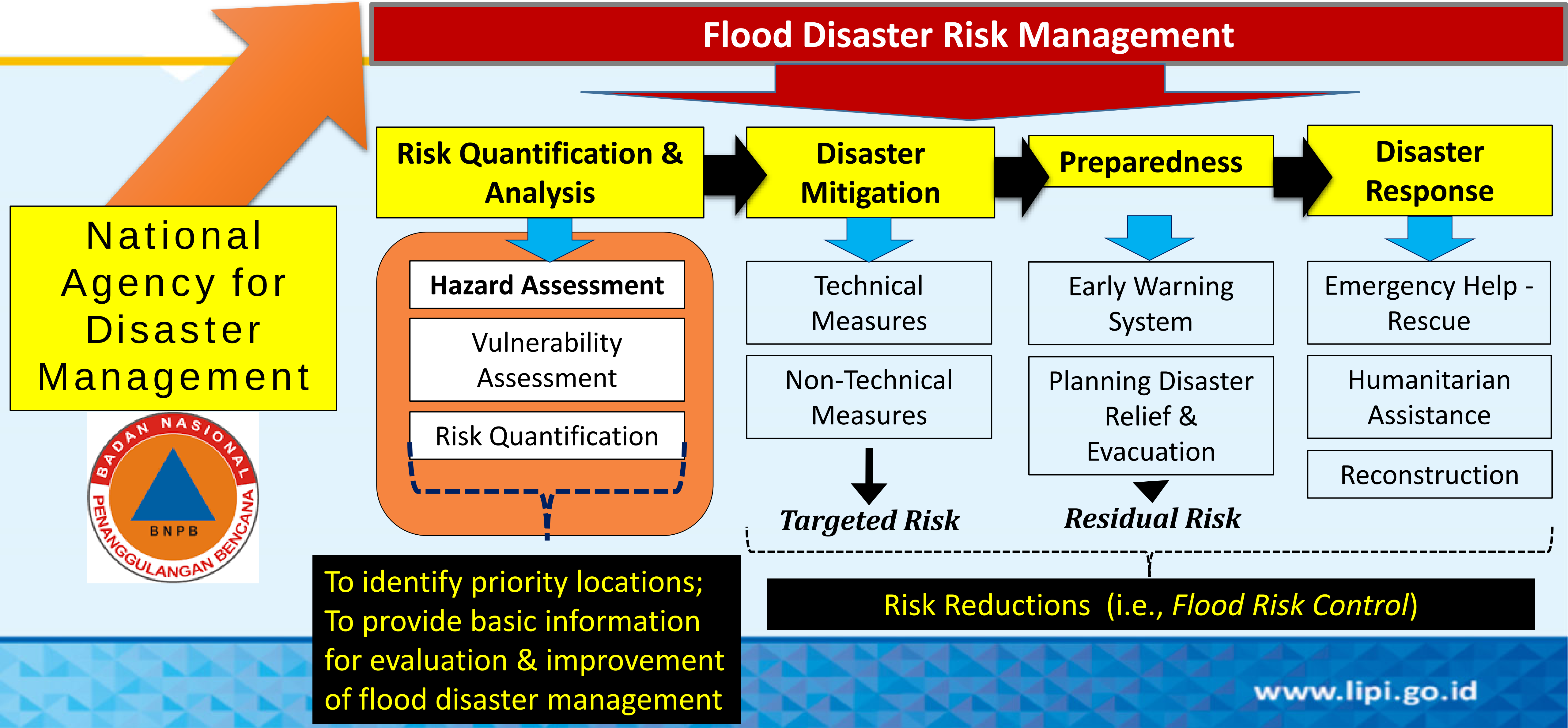
Existing Flood Hazard Map in the Batanghari River basin: District Scale



National Disaster Management Agency (BNPB)

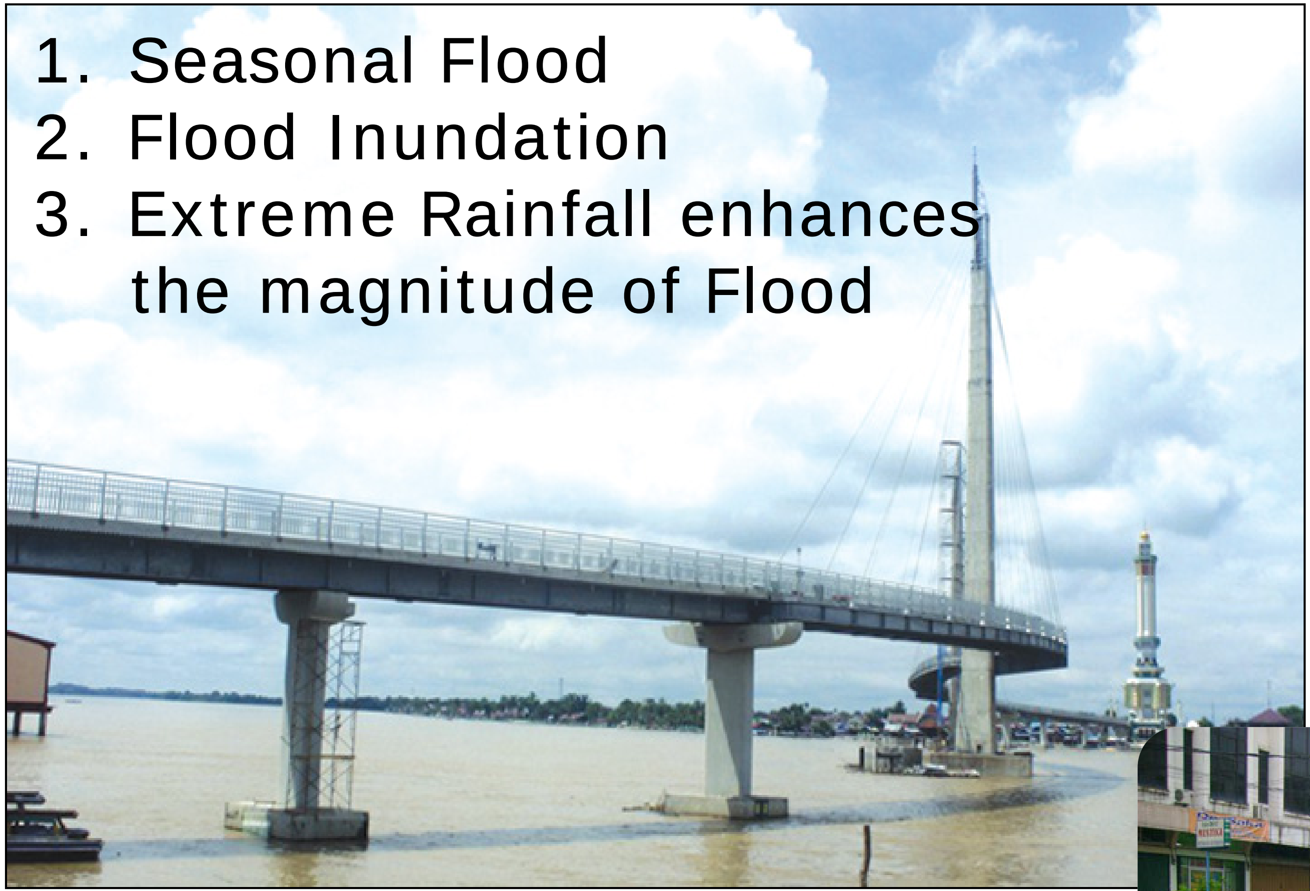
- Low resolution
- Created using Parametric Approach
- Qualitative information

I INTRODUCTION



Batanghari River

1. Seasonal Flood
2. Flood Inundation
3. Extreme Rainfall enhances the magnitude of Flood



Effects: Community livelihood, important economic sector (agriculture), freshwater ecosystem including peat land

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$$\text{Flood Risk} = \frac{\text{Flood Hazards} \times \text{Flood Exposures} \times \text{Flood Susceptibility}}{\text{Flood Control Measures}}$$

Flood Hazard Dimension: Flood Discharge (*q*), Inundation Depth (*h*), Inundation Area (*A*), Flood Duration (*t*)

Climate Change

Landuse Change

II. METHODOLOGY

PROCESS, DATA REQUIRED & TOOLS

Rainfall Projection (Seasonal & Extreme Conditions)

- 41 GCM Outputs

Land Use Projection

- Land use/Land Cover
- Population density
- Infrastructure map
- Digital Elevation Model
- Soil types

Flood Modeling

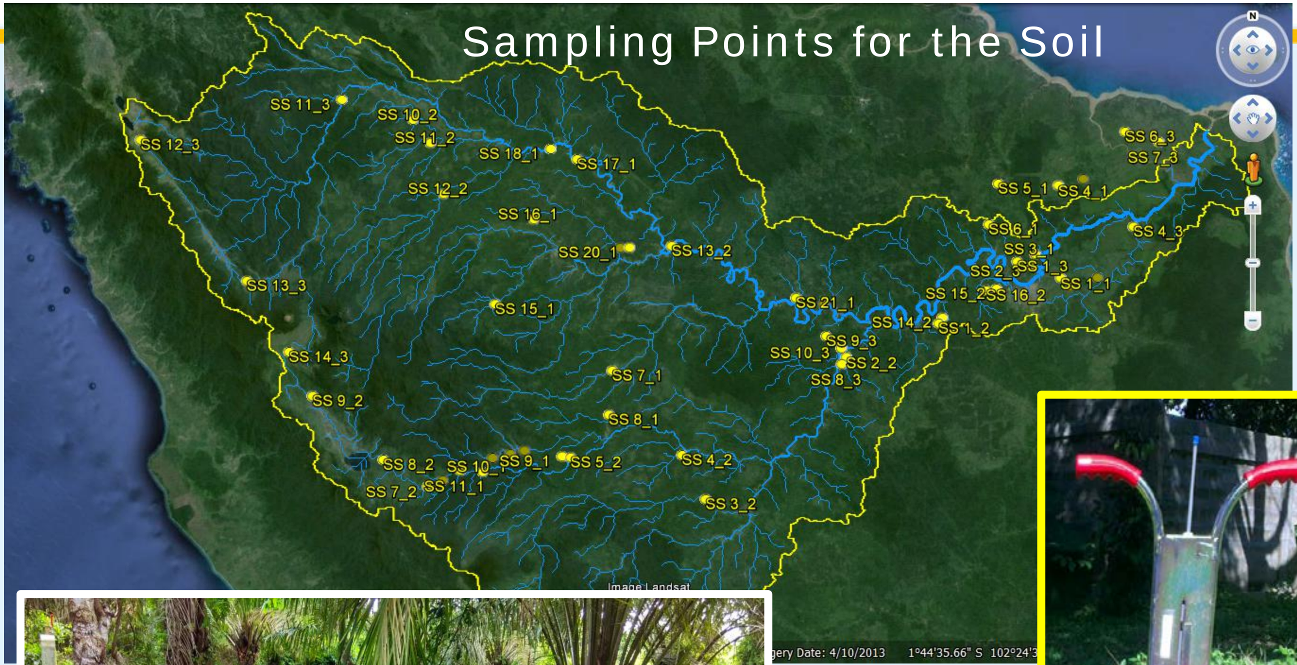
- Land use & Land use Projection
- Rainfall data
- Water discharge
- Stream network
- HydroSHEDS

TOOLS

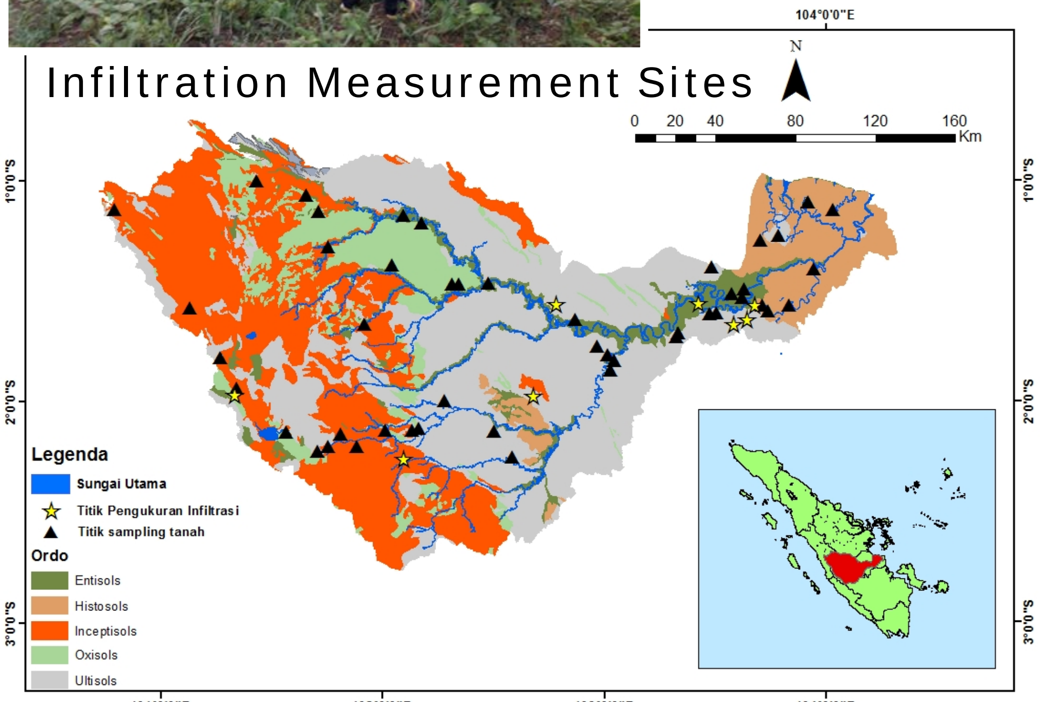
- Arc GIS version 10.2
- CLUE
- SPSS
- ERDAS
- RRI model (Fortran)

II. METHODOLOGY

Field Measurement Activity for Data Collection, Understanding the Process, Improvement of Hydrological Modeling system



Turf – tec infiltrometer



Primary Data of Soil Properties

- ✓Soil Properties Analysis: permeability, texture, organic matter, bulk density, porosity
- ✓Infiltration measurement

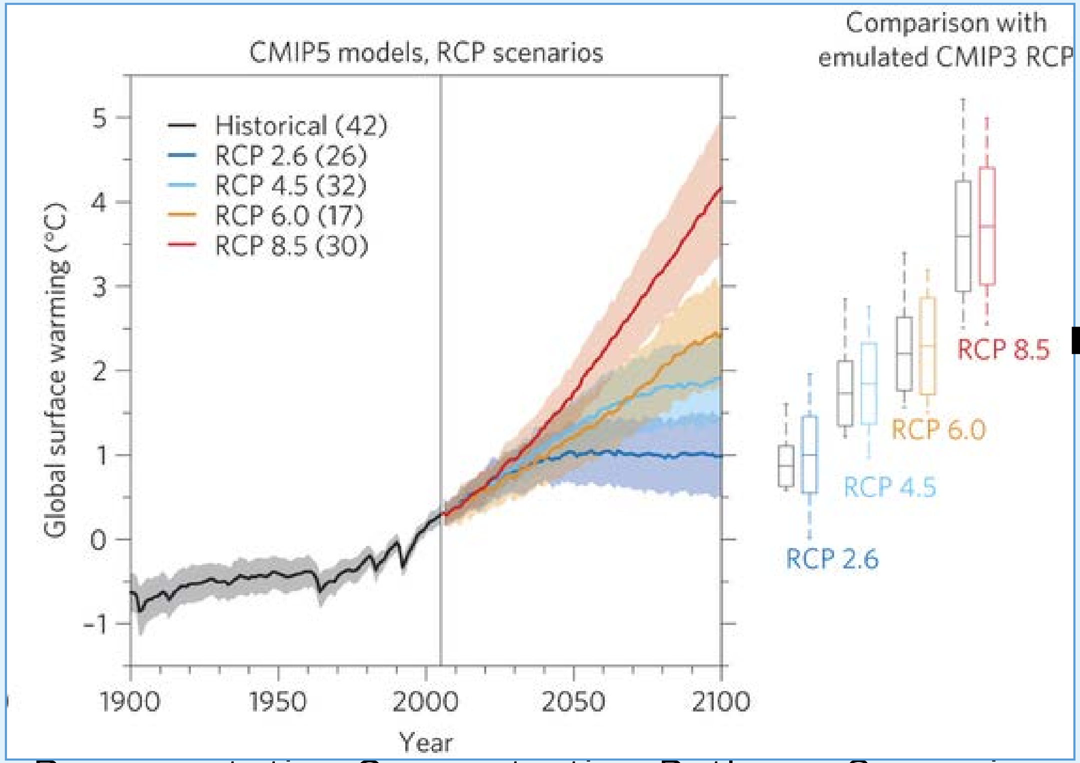
II. METHODOLOGY

Field Measurement Activity for Cross Section and River's Bathymetric at selected sites

Climate Projection Data

- **SOUSEI Program (Japan): MRI-AGCM 20-km**
- **SimCLIM (New Zealand): 40 Ensembel GCMs**

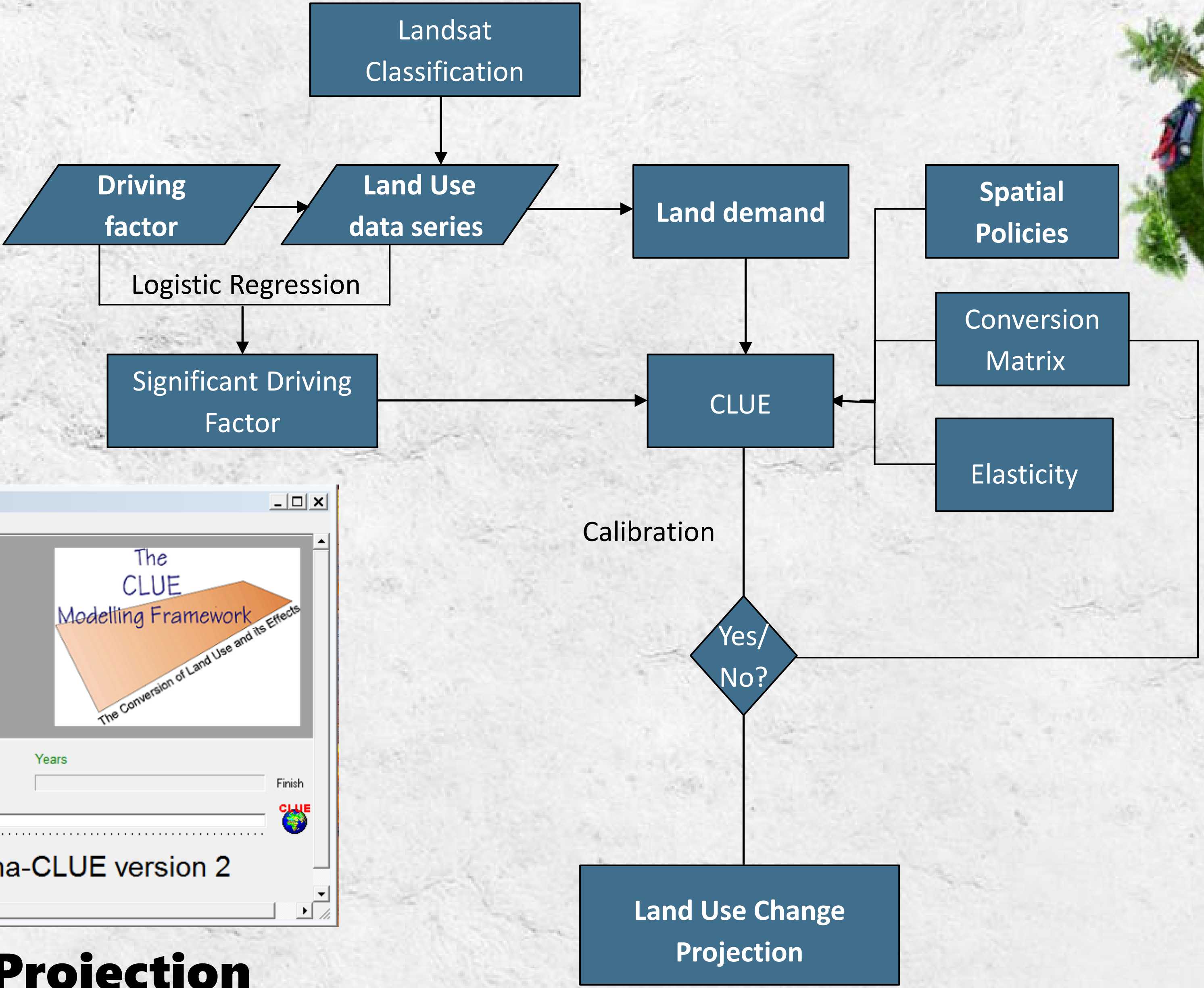
Climate Projection Data for Different RCPs (2.6 - 8.5) Scenario

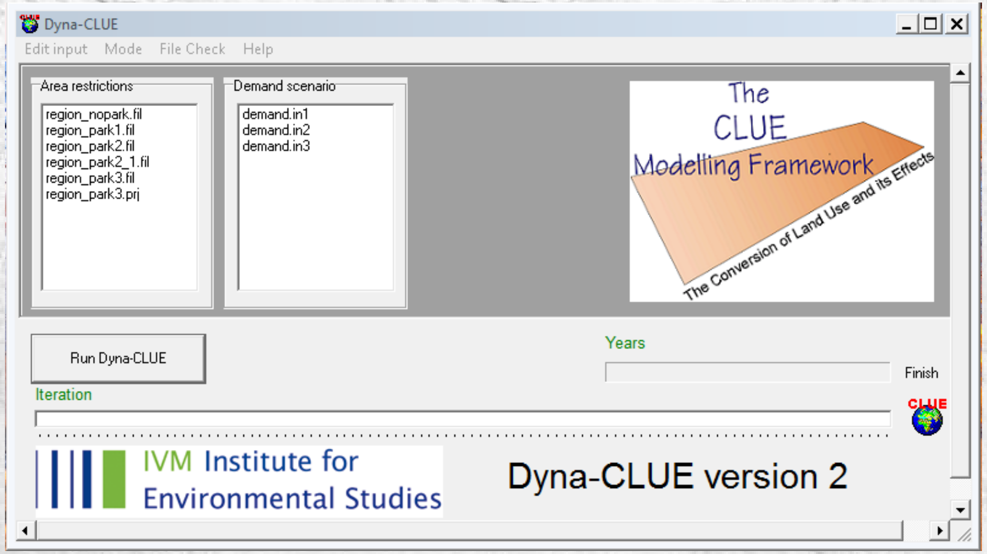


Representative Concentration Pathway Scenarios (RCPs), AR5

Seasonal & Extreme Rainfall Analysis

II. METHODOLOGY





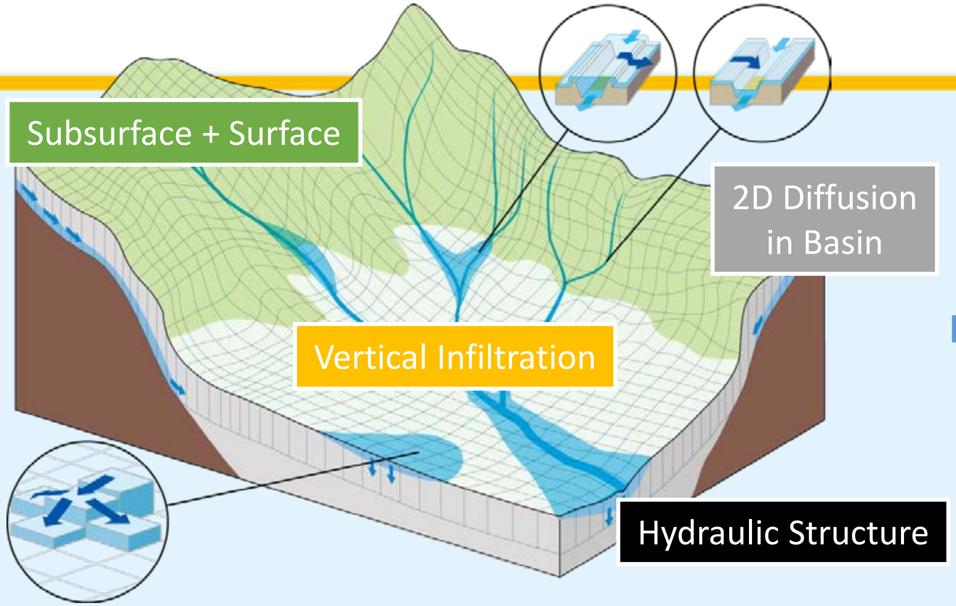
Land Use Change Projection

Rainfall-Runoff-Inundation Model

Sayama *et al* (2008)

Input

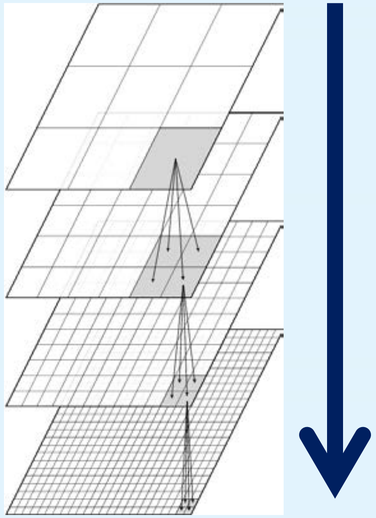
- Rainfall
- DEM
- Land Cover
- Socio-Economy
- Cross Sec.



Output

- Discharge
- Water Level
- Inundation
- Damage Cost
- Mitigation Strategy

Flood risk at District Scale



500-m grid size, 1-hr time interval

Shallow water equations for typical 2D inundation

Mass balance equation

$$\frac{\partial h}{\partial t}+\frac{\partial q_x}{\partial x}+\frac{\partial q_y}{\partial y}=r$$

Momentum equations

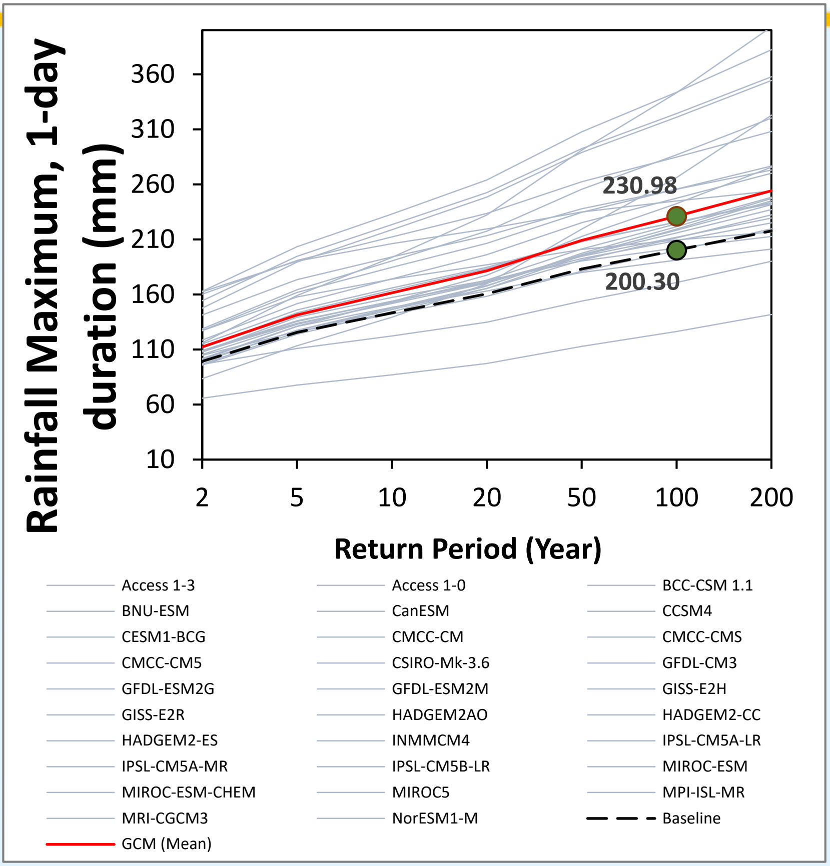
$$\frac{\partial q_x}{\partial t}+\frac{\partial u q_x}{\partial x}+\frac{\partial v q_x}{\partial y}=-gh\frac{\partial H}{\partial x}-\frac{\tau_x}{\rho_w}$$

$$\frac{\partial q_y}{\partial t}+\frac{\partial u q_y}{\partial x}+\frac{\partial v q_y}{\partial y}=-gh\frac{\partial H}{\partial y}-\frac{\tau_y}{\rho_w}$$

III. RESULTS: PROGRESS

Extreme Rainfall Projection

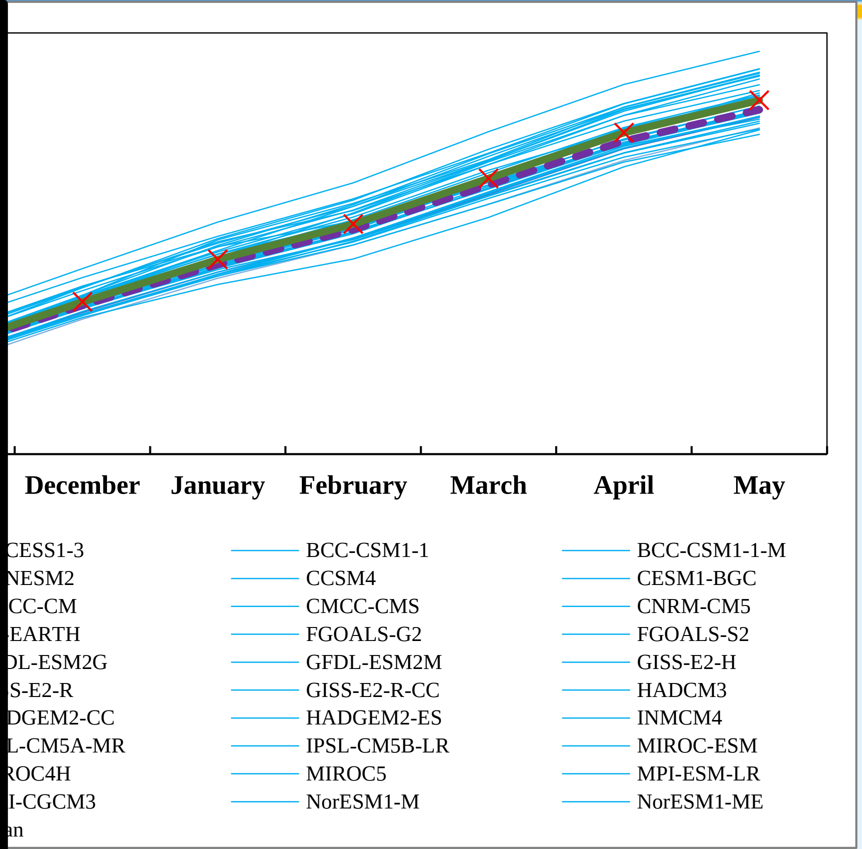
(L-Moment Method was used)



In average, the extreme rainfall with 1-day duration and 100-year retun period will increase 10%

Seasonal Cumulative Rainfall Projection (Rainy)

Bulan	Rata-Rata Perubahan CH Bulanan
JAN	**17,8%**
FEB	0,7%
MAR	-6,6%
APR	-1,0%
MEI	-3,9%
JUN	4,9%
JUL	3,7%
AGT	**-13,3%**
SEP	**-7,7%**
OKT	-1,1%
NOV	3,5%
DES	**22,1%**
AVERAGE	**1,6% ± 9,7**



e monthly rainfall amount will ason of the future climate condition 3

III. RESULTS: PROGRESS

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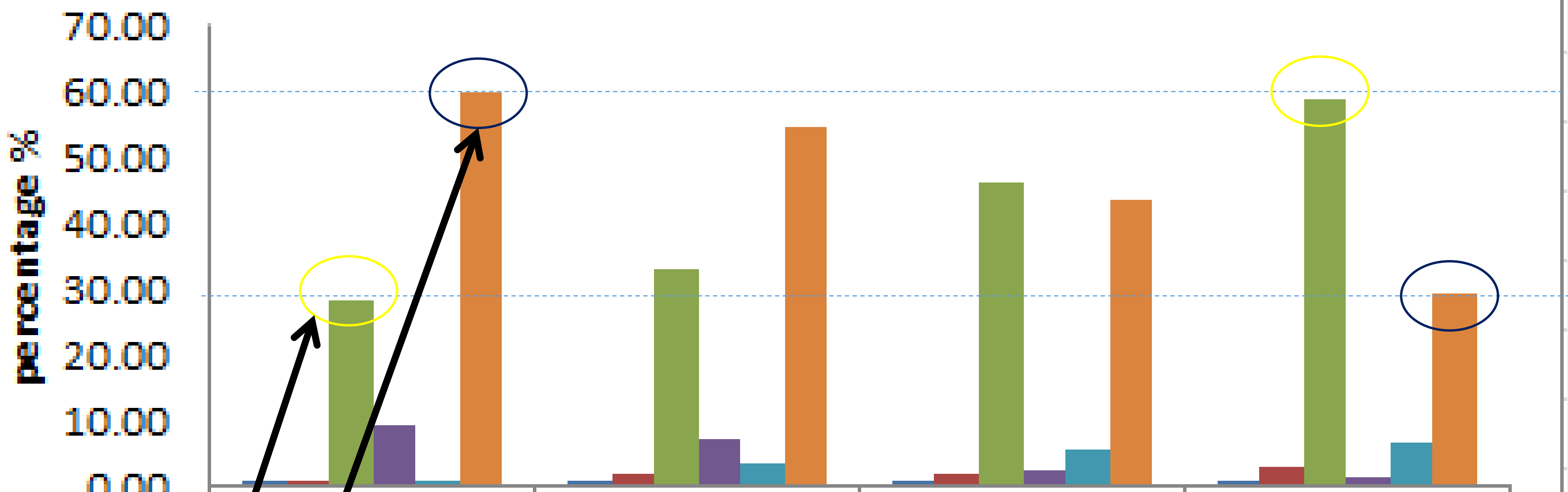
Landuse Changes

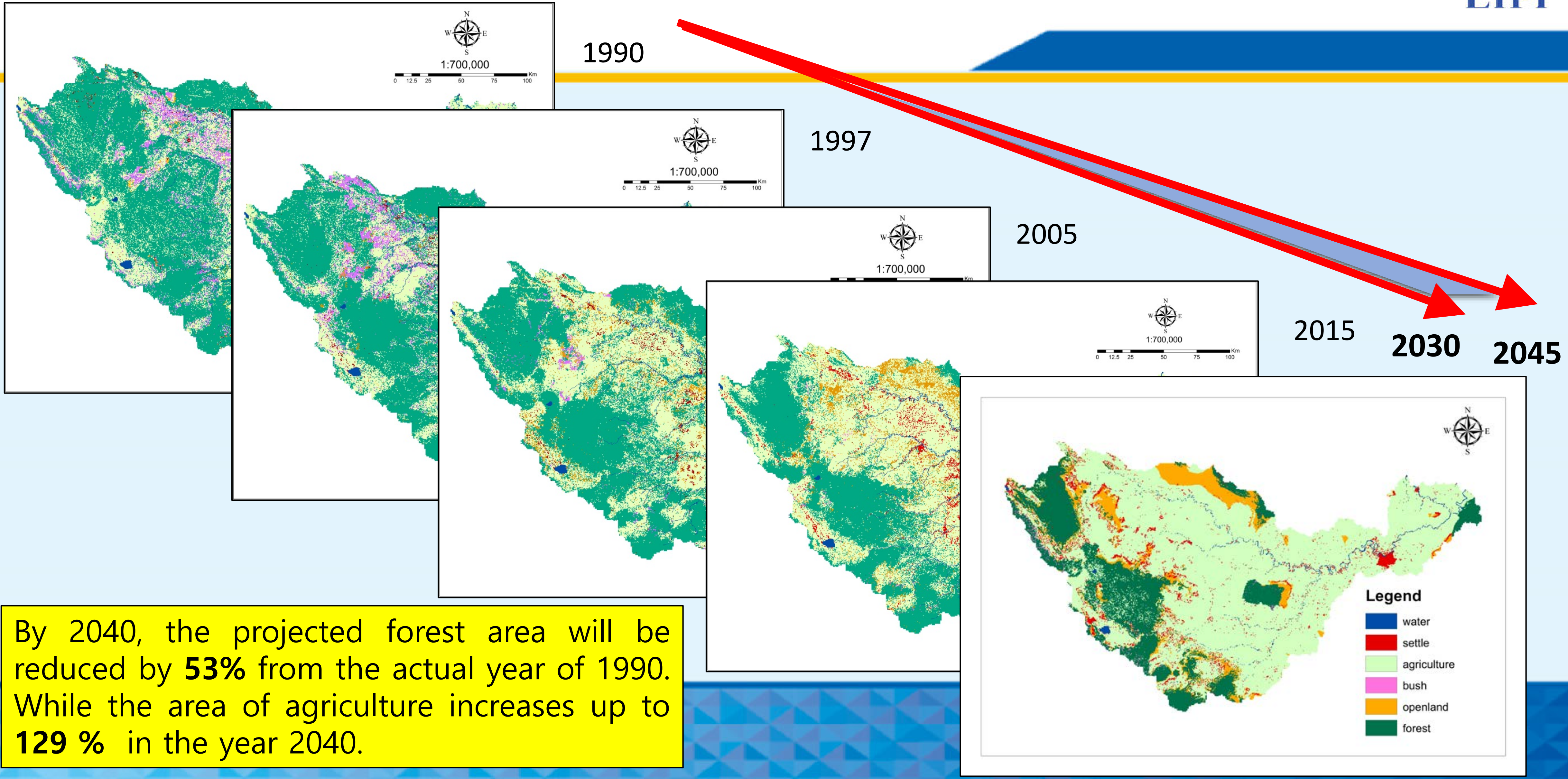
Land use in1990, 1997, 2005 and 2015 (left to right)



	1990	1997	2005	2015
Water Body	0.96	0.96	0.96	0.96
Settlement	0.90	1.68	1.97	3.08
Agriculture	28.22	32.99	45.99	58.75
Bush	9.26	7.03	2.56	1.43
Open land	1.11	3.27	5.40	6.70
Forest	59.56	54.07	43.12	29.08

III. RESULTS: PROGRESS

Historical, Present & Future Landuse Conditions



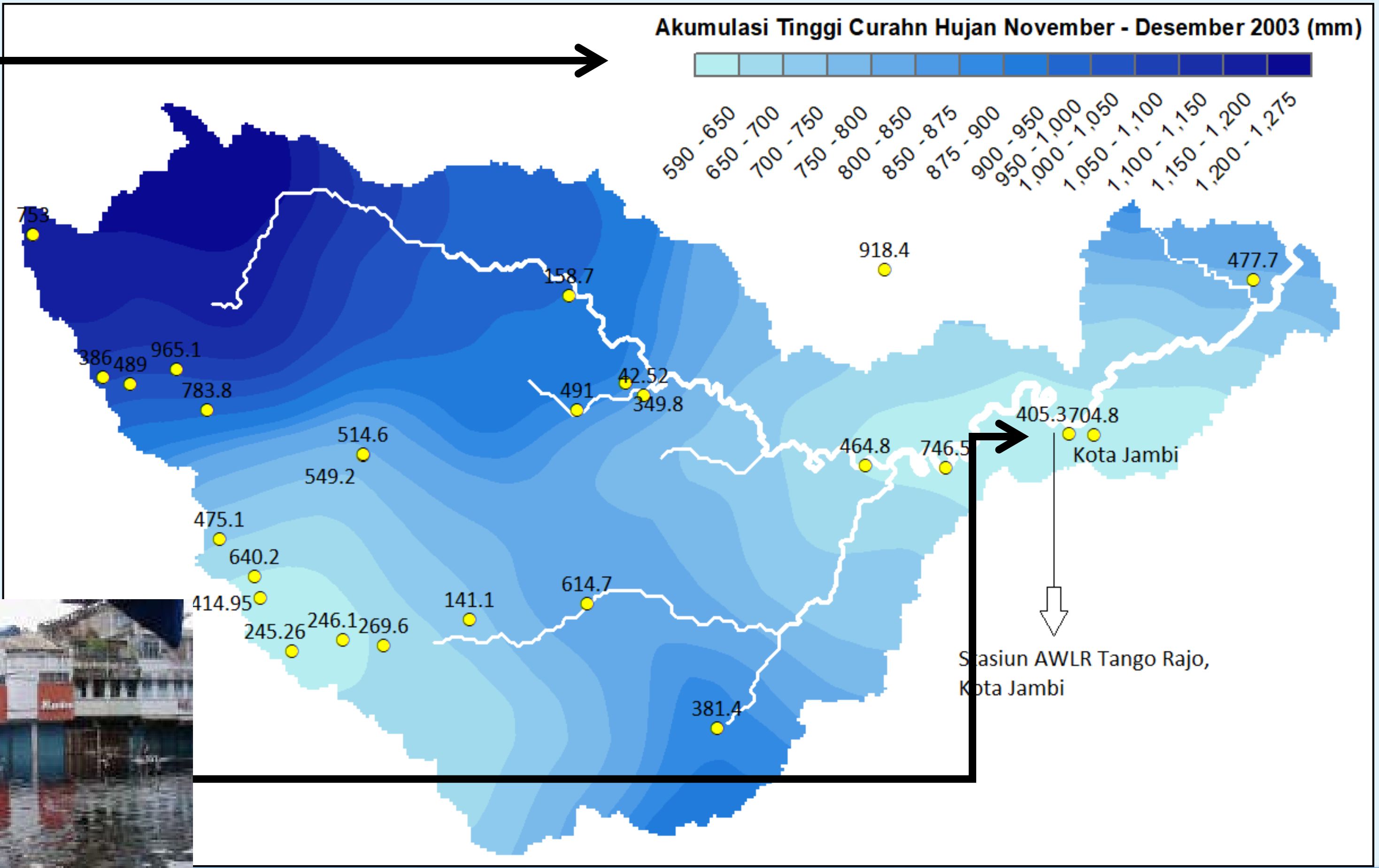
By 2040, the projected forest area will be reduced by **53%** from the actual year of 1990. While the area of agriculture increases up to **129 %** in the year 2040.

III. RESULTS: PROGRESS

Reconstruction of Historical Flood Event on Nov-Dec 2003. It was for Producing a Flood Hazard Map derived from the Past Worst Flood Event Condition

Cumulative Rainfall during the Period of Nov - Dec 2003 (mm)

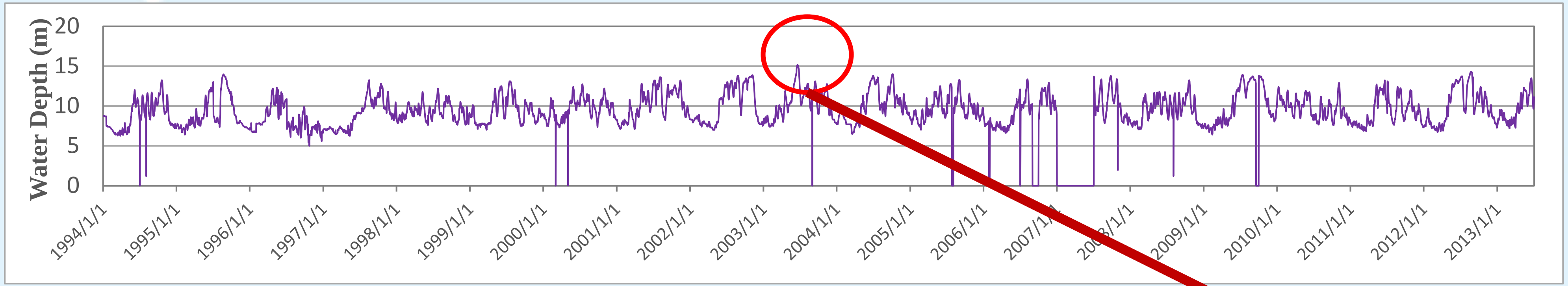
1. GSMaP Reanalysis Data
2. Gauging Stations Data



III. RESULTS: PROGRESS

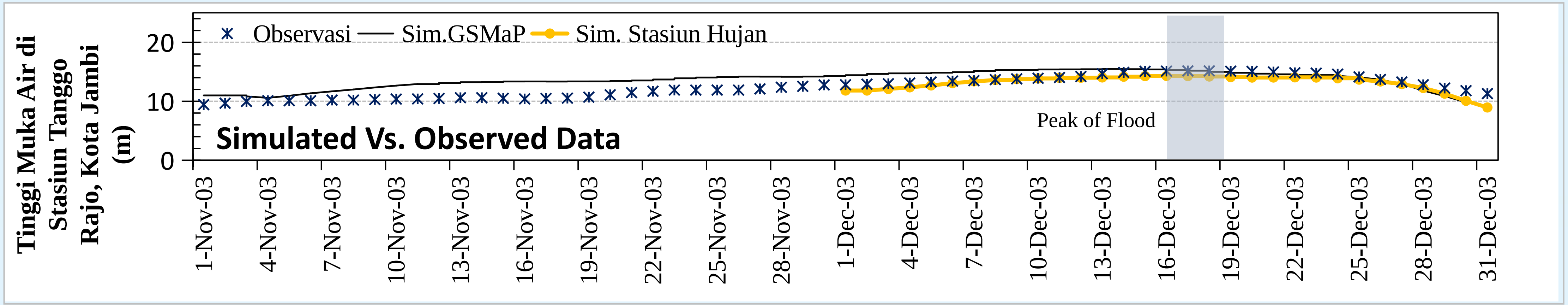
Flood Model Performance in Simulating Hazard Dimension

Batanghari Flood, Nov - Desember 2003 (50-Year Return Period)



Observed Water Level Data at Jambi City Station

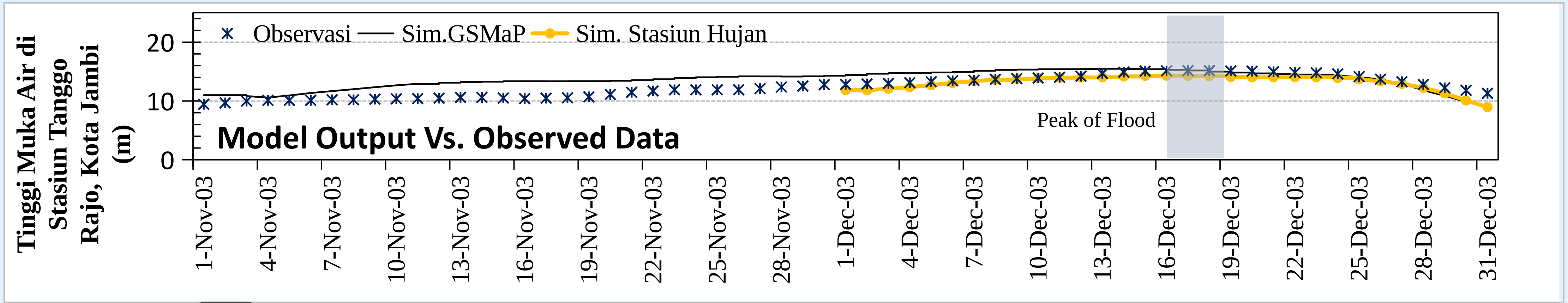
Simulation Result



III. RESULTS: PROGRESS

Flood Model Performance in Simulating Hazard Dimension

Batanghari Flood, Nov - Desember 2003 (50-Year Return Period)



Index Performance / Simulation With:	**Sim. GSMaP**	**Sim. Stasiun Hujan**
$RE = \left(\frac{h_{max.sim} - h_{max.obs}}{h_{max.obs}} \right) x\,100\%$		

Information:

RE = Relative Error (%)

$h_{max \cdot sim}$ = Simulated Max.Water Level during Peak of Flood

$h_{max.obs}$ = Simulated Max.Water Level during Peak of Flood

Sim. Stasiun Hujan = Gauging Station

Sim.GSMaP = GSMaP Reanalysis

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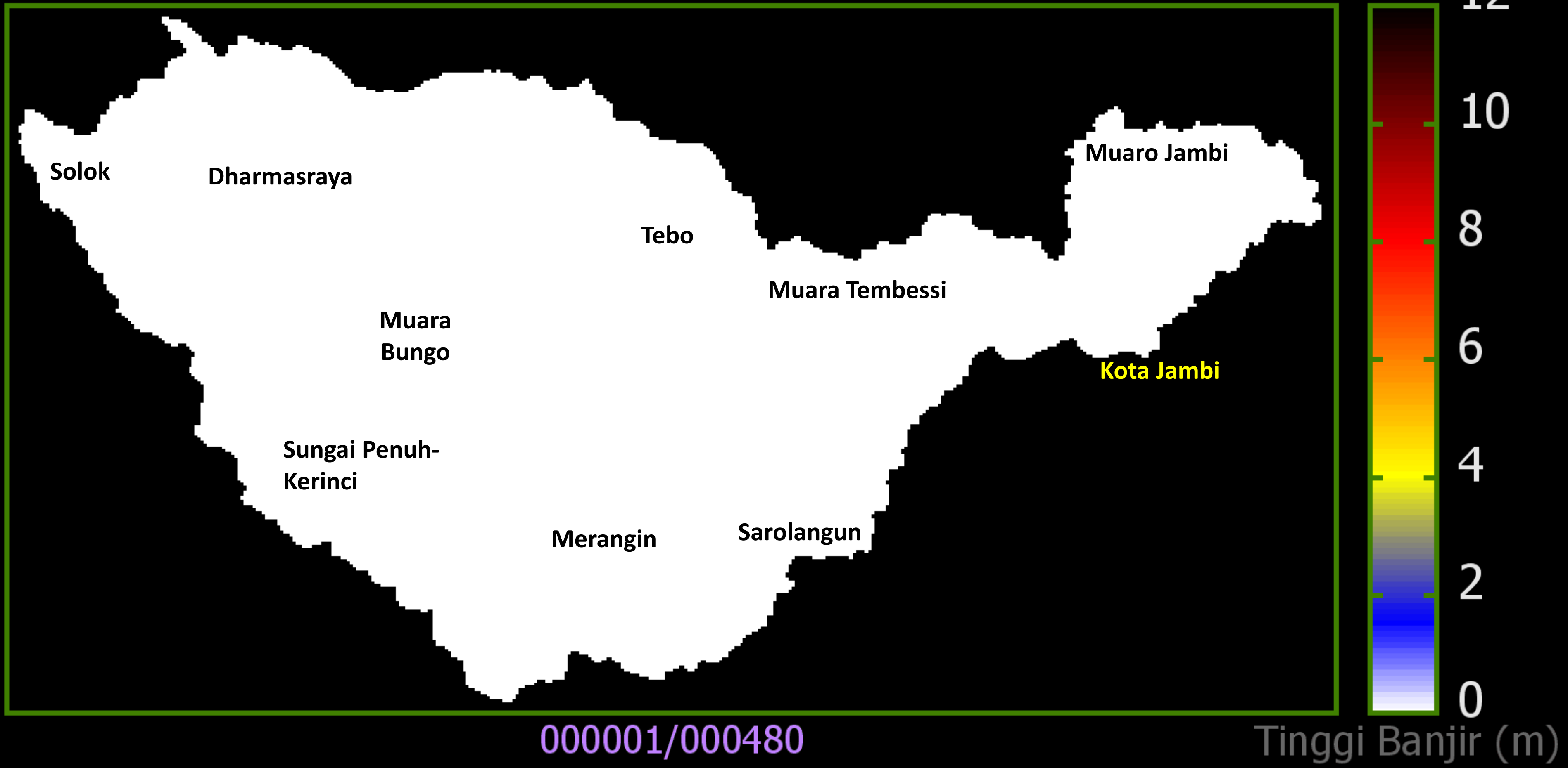
Simulated Flood Water Propagation during the Flood Event on November - December 2003:

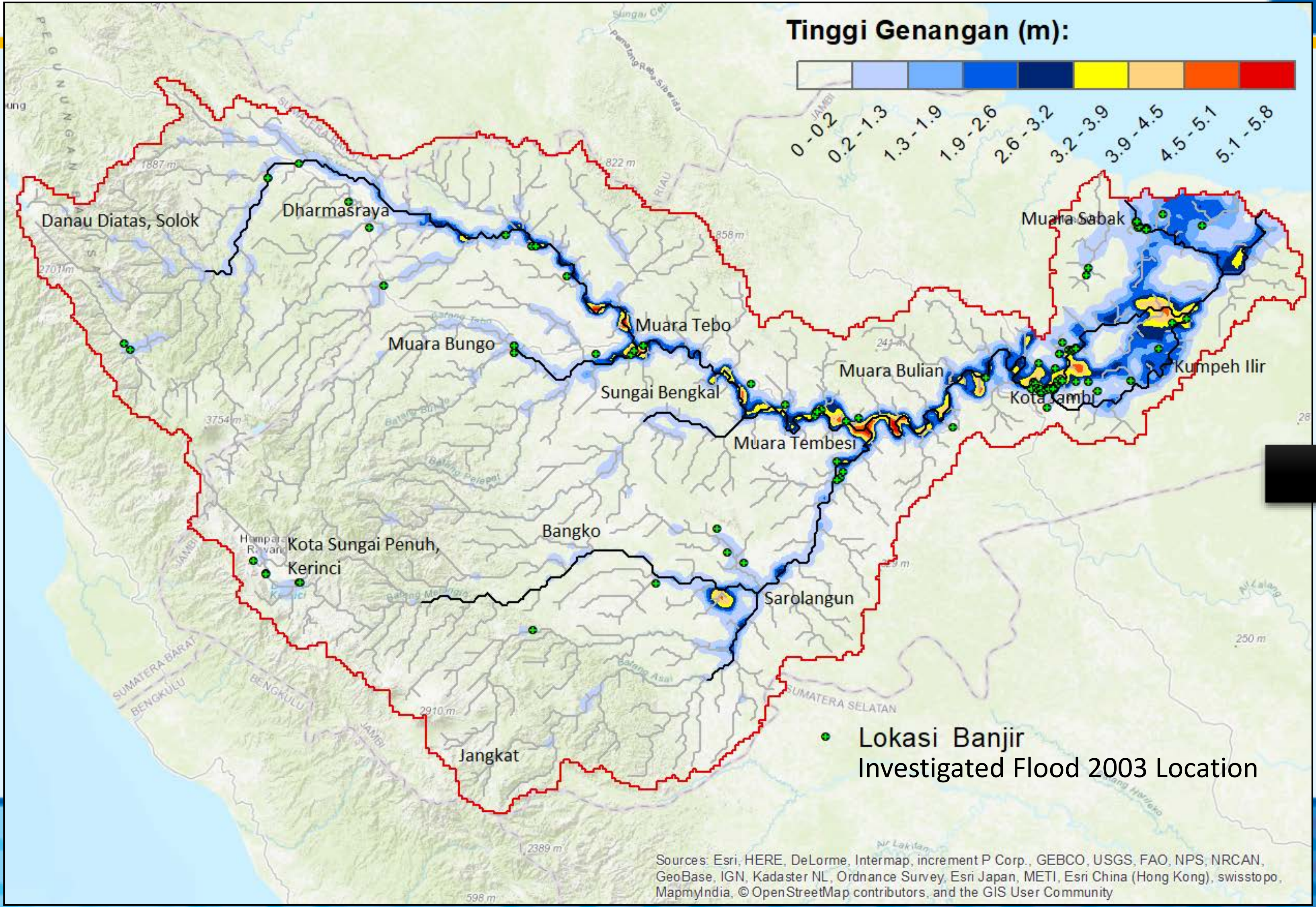


Dynamic Changes of the Area and Flood Depth

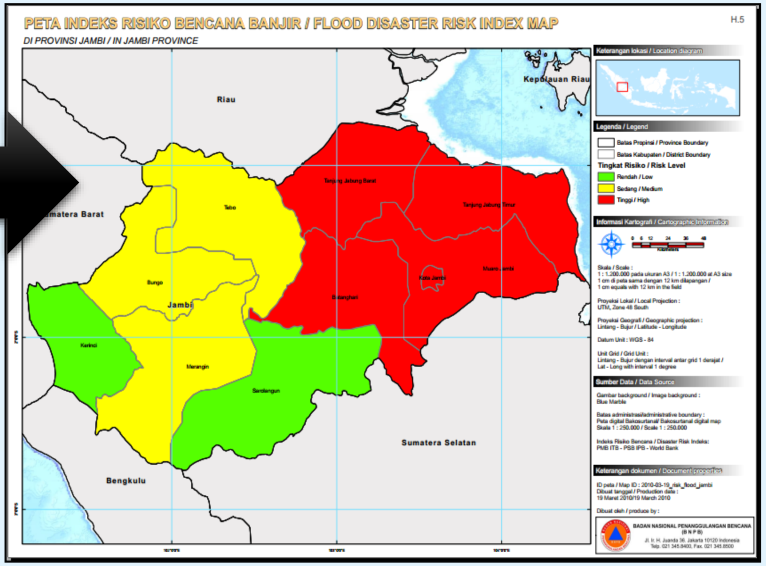
III. RESULTS: PROGRESS

Spatial Flood Hazard Information for the Present Climate Condition in the Batanghari River basin

Flood Depth (mm)



National Disaster Management Agency (BNPB)



III. RESULTS: PROGRESS

Flood Hazard Mapping

Dissemination & Disccussion with stakeholders and local peopole

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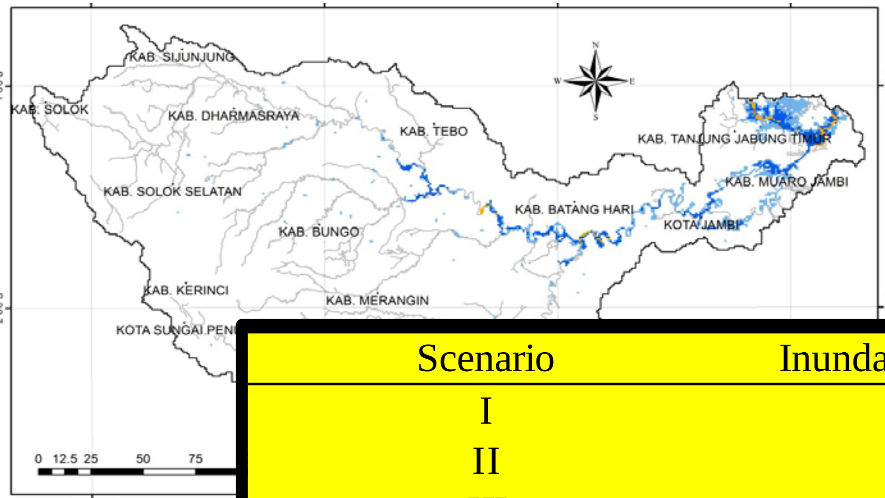
Projection of Climate and Landuse Changes Impact on the Future Flood Hazard

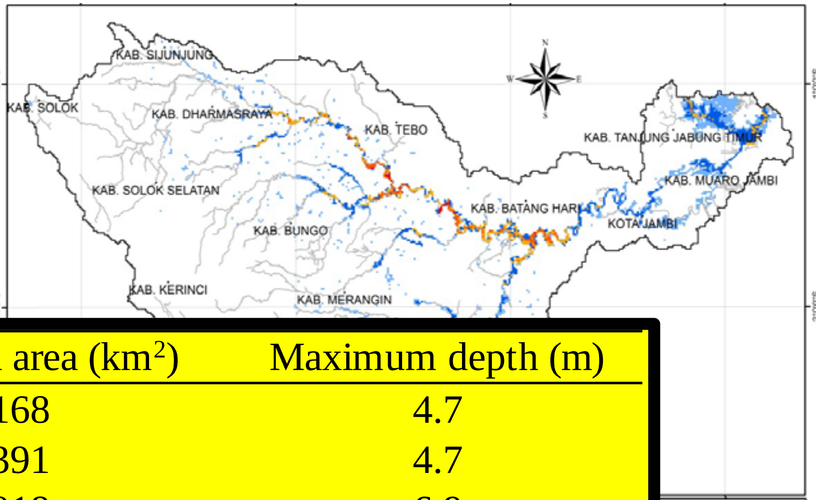
Extreme Rainfall:

Return Period (Year) for 1-day duration	Present Climate (mm)	Future Climate (mm)
2	32	45
5	45	68
10	56	88
30	76	127
50	87	151
100	105	189
200	125	235

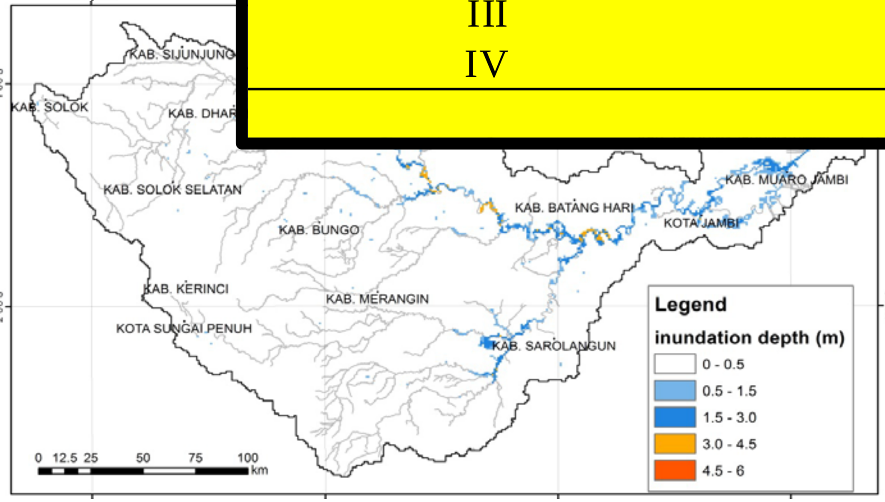
Projected flood inundation area for Land use 2015 & Present Climate (Scenario I)



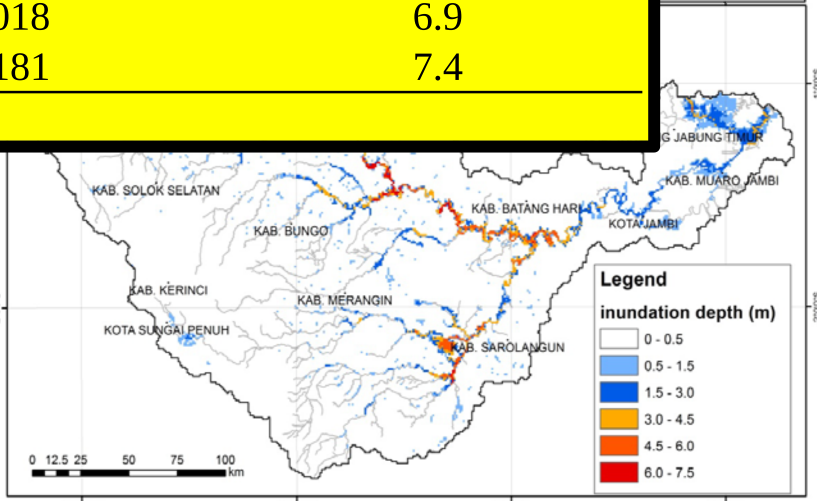
Projected flood inundation area for Land use 2015 & Future Climate (Scenario III)



Scenario	Inundated area (km^2)	Maximum depth (m)
I	1168	4.7
II	1391	4.7
III	2018	6.9
IV	2181	7.4



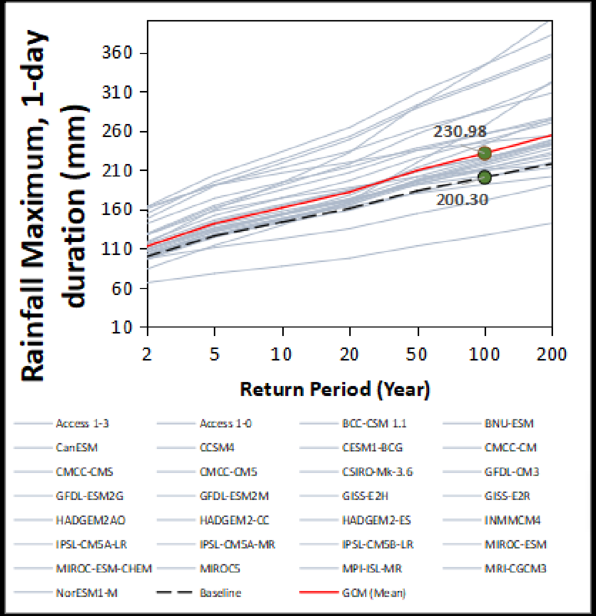
Projected flood inundation area for Land use 2040 & Present Climate (Scenario II)

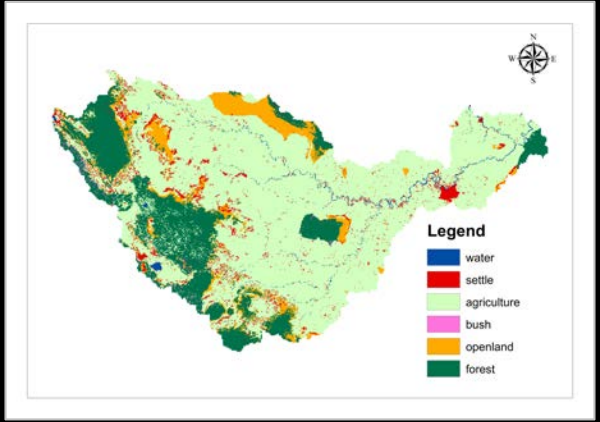


Projected flood inundation area for Land use 2040 & Future Climate (Scenario IV)

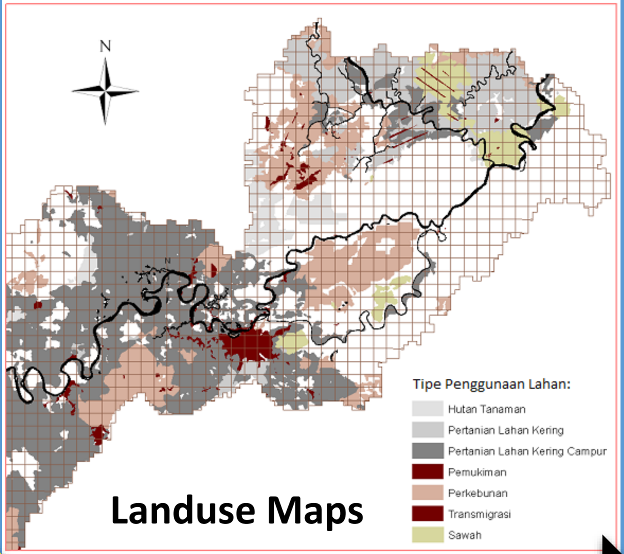
IV. FURTHER WORKS

Baseline & Projected Extreme Rainfall & Landuse





Downstream Area of Batanghari



Landuse Maps

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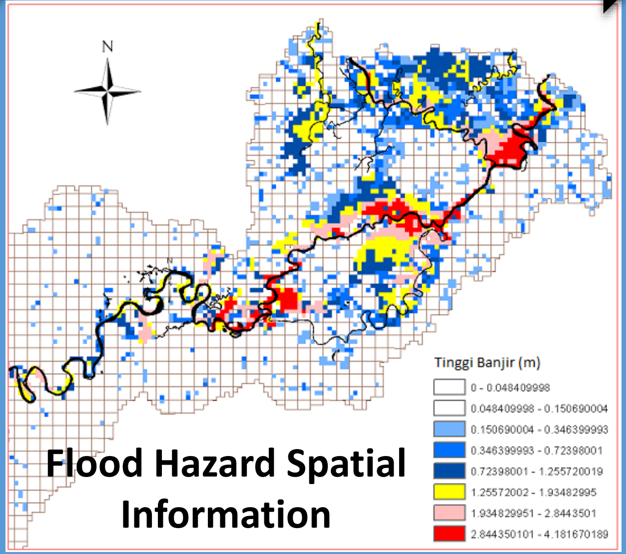
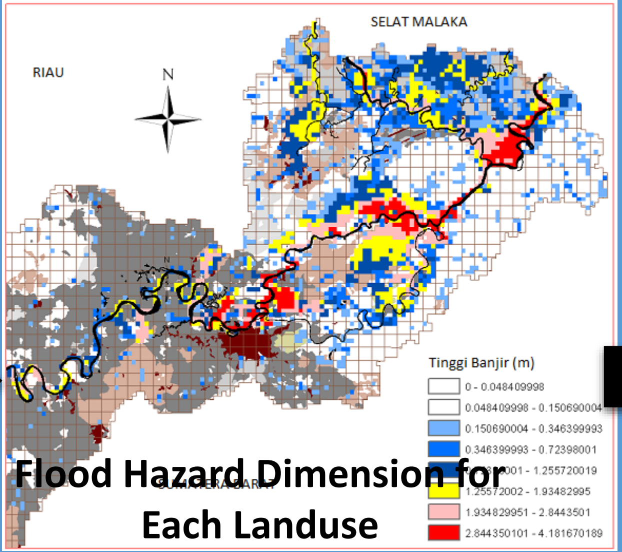


Flood Hazard Spatial Information



Flood Hazard Dimension for Each Landuse

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Perkiraan Nilai Kerusakan dan Kerugian Sektor Infrastruktur

Sektor & Sub-sektor	Nilai (juta rupiah)			Kepemilikan (juta rupiah)	
	Kerusakan	Kerugian	Total	Publik	Swasta/masyarakat
Transportasi Darat	**271,149.88**	**330,240.00**	**601,389.88**	**281,389.88**	**320,000.00**
1 Jalan dan Jembatan	257,021.88		257,021.88	257,021.88	
2 Kereta api	14,128.00	9,240.00	23,368.00	23,368.00	
3 Jalan tol		1,000.00	1,000.00	1,000.00	
4 Bus Way & Organda		320,000.00	320,000.00	-	320,000.00
Energi	**22,768.00**	**175,600.00**	**198,368.00**	**198,368.00**	
1 Listrik	22,768.00	75,600.00	98,368.00	98,368.00	
2 Depo Bahan Bakar Umum	NA	100,000.00	100,000.00	100,000.00	
Pos dan Telekomunikasi	-	**18,000.00**	**18,000.00**	**18,000.00**	
Air dan Sanitasi	**15,400.00**	**2,000.00**	**17,400.00**	**17,400.00**	
Infrastruktur Pertanian	**18,652.22**	-	**18,652.22**	**18,652.22**	-
1 Irigasi Teknis	5,044.30		5,044.30	5,044.30	
2 Irigasi Non-teknis	80.00		80.00	80.00	
3 Irigasi Sederhana	20.00		20.00	20.00	
4 Tanggul & Tebing	12,836.00		12,836.00	12,836.00	
5 Pintu air	671.92		671.92	671.92	
Total	**327,970.10**	**525,840.00**	**853,810.10**	**533,810.10**	**320,000.00**

Sumber: Departemen PU, Pemprov Jabar, Kabupaten Tangerang, Kabupaten Bekasi, PDAM Kab. Bogor, PT PLN & Media, Februari 2007

Damage Curve

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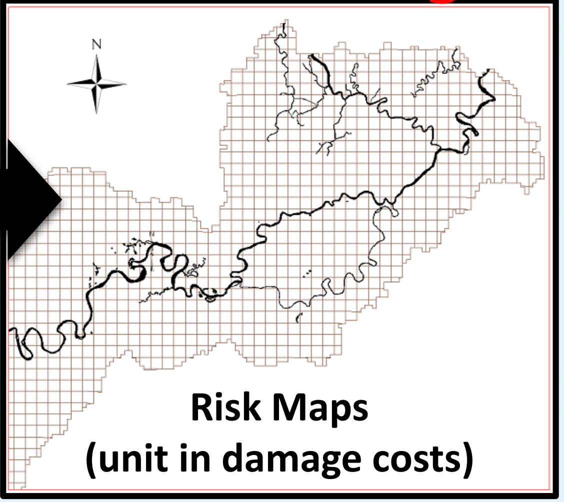
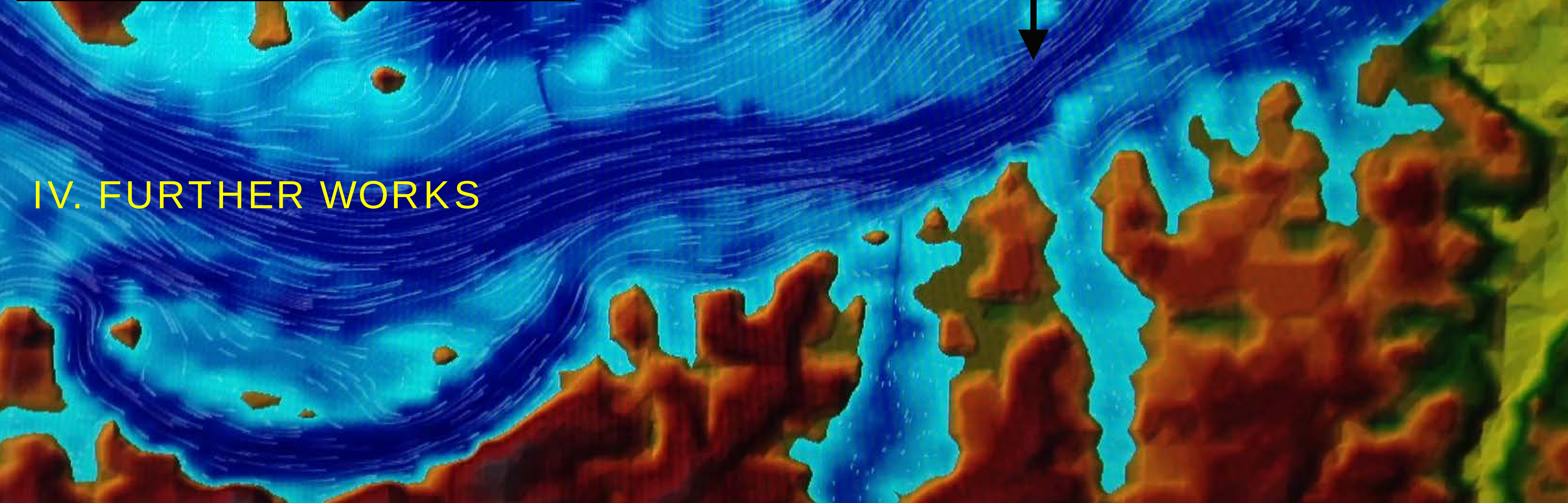
in Processing



Risk Maps
(unit in damage costs)

Spatial quantification of flood hydrodynamic & hazard for the local scale (hot spot areas), such as Jambi City Area:

1. Detail flood hazard and risk
2. Flood mitigation
3. Aquatic ecosystem restoration



IV. FURTHER WORKS

V. SUMMARY

1. Quantitative flood hazard assessment with considering climate change and anthropogenic factors, have been made and applied in the Batanghari River basin;
2. Physically-based distributed hydrological modeling system, called as rainfall-runoff-inundation model, was used as the main method in quantifying flood hazard dimensions (*q*, *h*, *A*, *t*);
3. The greatest land conversion in Batanghari river basin was forest area into agriculture area. Forest area is predicted to decline continously until the next 30 years. While agricultural always expand along with the increasing of population;
4. Based on the simulation, in 2040 inundation area will be wider than area in 2015. Which means that there will be a potential changes on flood hazard dimension in response to climate and landuse changes in the future.

Thank You

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