Climate Change Impact on Urban Drainage in Coastal Belt of Bangladesh

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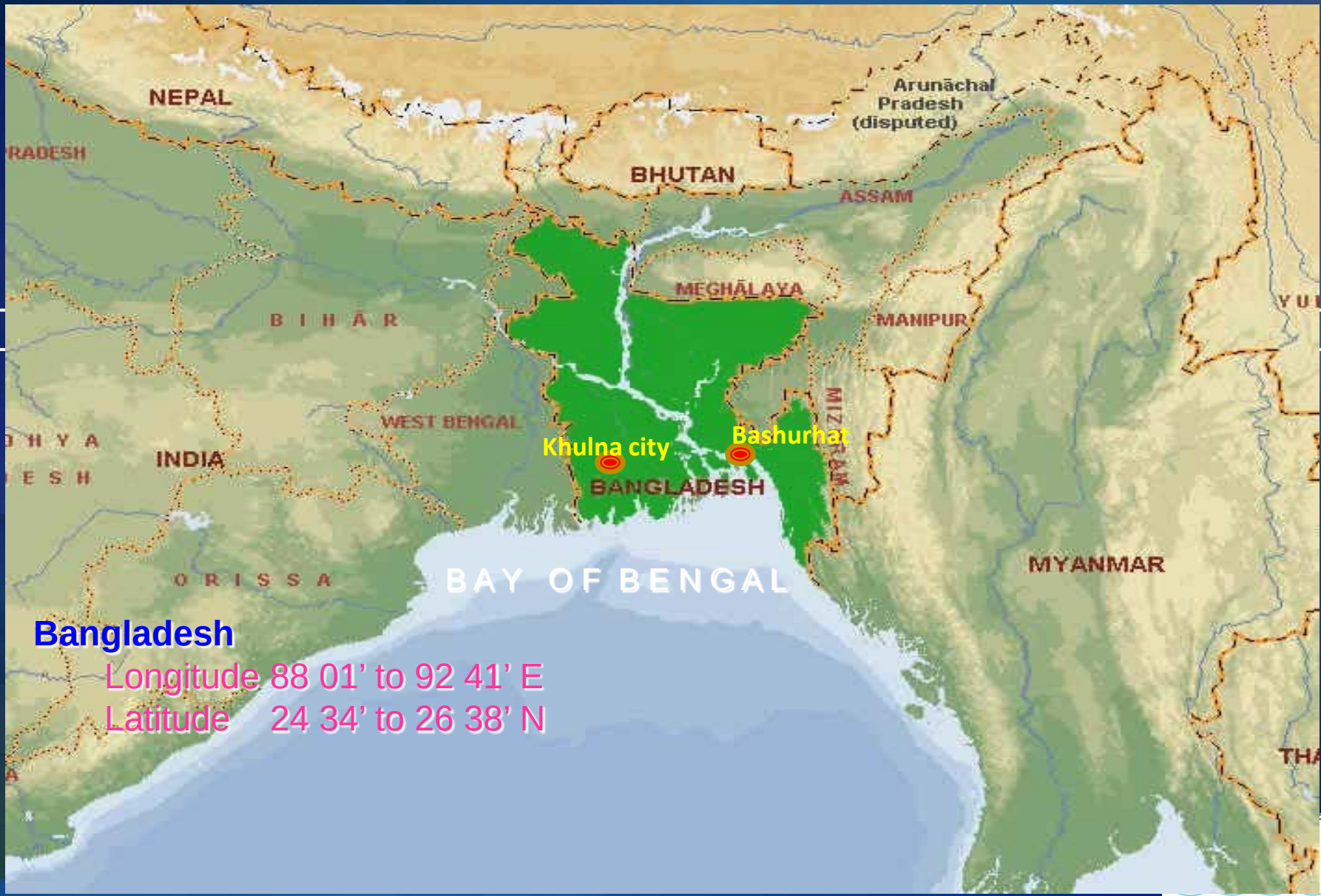
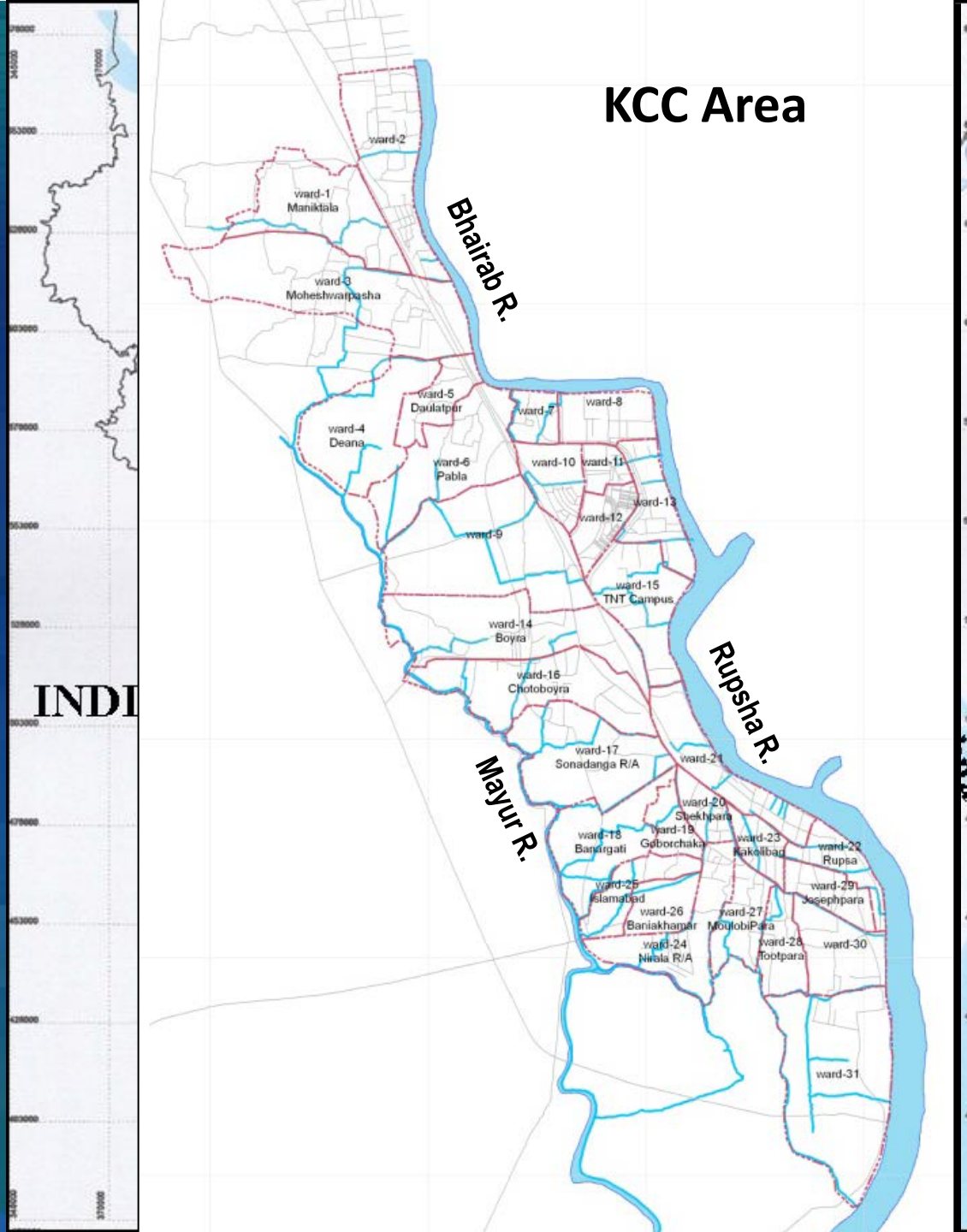
Study Area


NEPAL
Arunāchal Pradesh (disputed)
BHUTAN
ASSAM
MEGHĀLAYA
MANIPUR
BIHĀR
WEST BENGAL
INDIA
Khulna city
Bashurhat
BANGLADESH
MIZRAM
MYANMAR
ORISSA
BAY OF BENGAL
Bangladesh
Longitude 88 01’ to 92 41’ E
Latitude 24 34’ to 26 38’ N

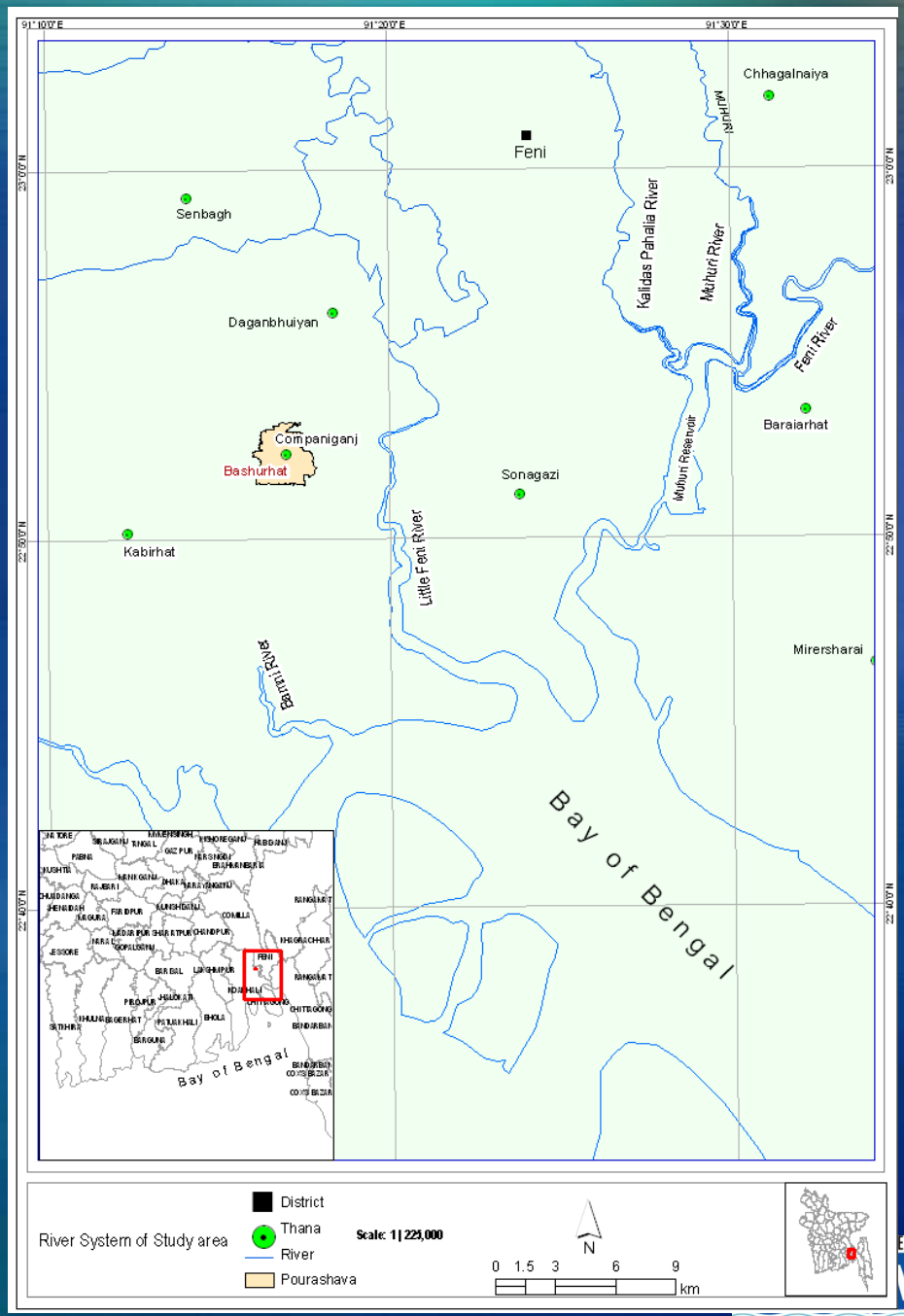
Khulna City

- 3rd largest City in Bangladesh
- Area 45 km^2
- Population is 1.5 million
- 2.5 m above MSL

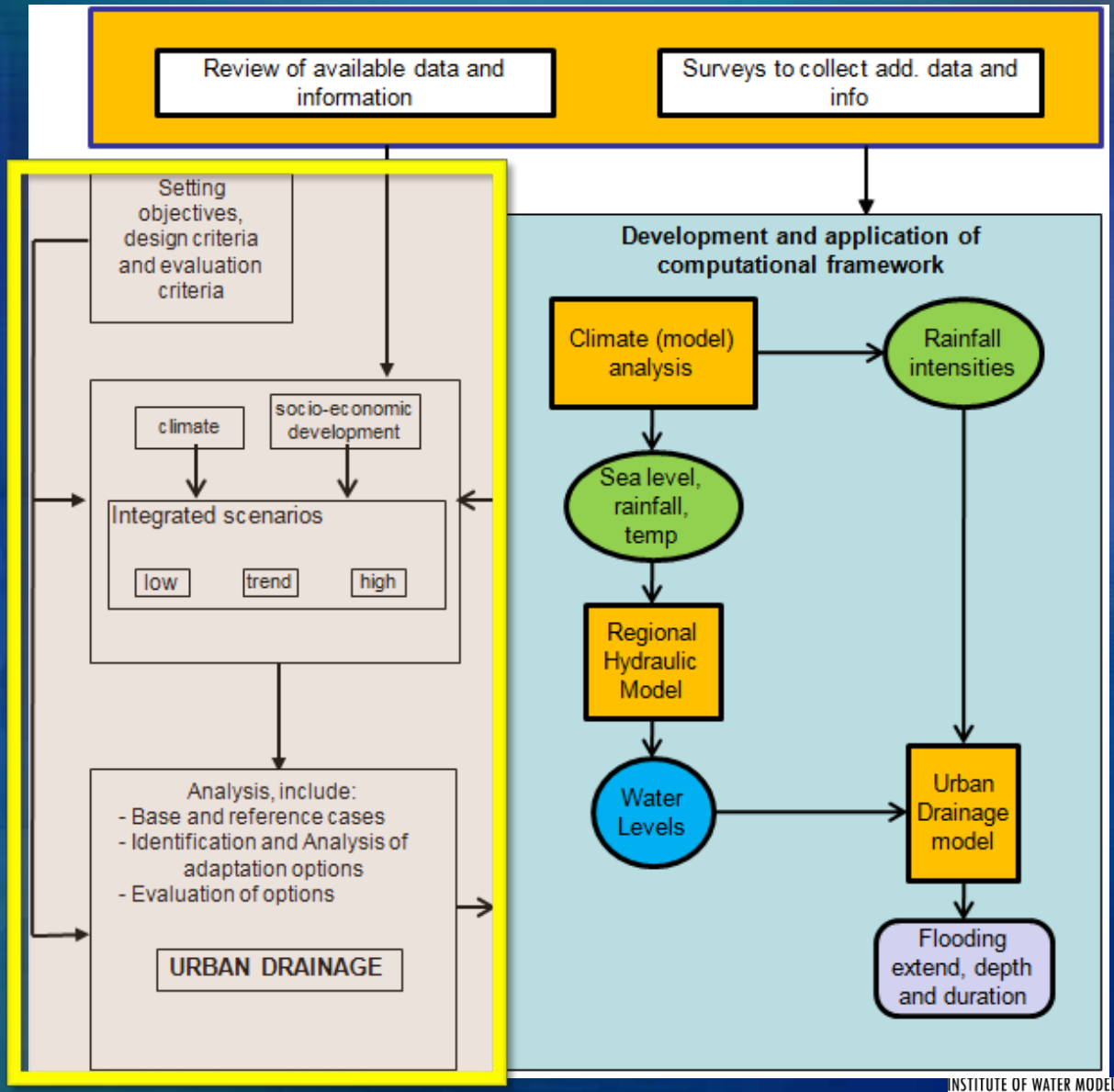


Bashurhat

- Small City in SE of Bangladesh
- Area 6.82 km^2
- Population is 215,000
- Drainage congestion in monsoon
- Only regulator does not work



Approach and Methodology



Scenario Development

- Socio-economic scenarios
  - Trend: expected developments
- Climate change scenarios
  - A2 – High CO_2 emissions
  - B1 – Low CO_2 emissions
- Time horizons for scenario's: 2030 and 2050

Population
Income
Agriculture
Industry
Manufacturing
Services
Housing
Landuse

Scenario Definitions

- Base cases:
  - analysis of present situation, 2030 and 2050
    - with socio-economic developments
    - but without climate change
- Reference cases:
  - analysis of future situations (2030 and 2050) if we do nothing
    - with climate change (A2 & B1)
    - with socio-economic developments
  - reference cases describing our future problems, to be solved by taking adaptation measures

Scenarios

Climate / Socio-economic	2010	2030			2050		
	Present	No climate change	A2	B1	No climate change	A2	B1
Trend	√	√	√		√	√	

Difference = impact of CC in 2030

Difference = impact of CC in 2050

Base cases

Reference cases

ADAPTATION MEASURES REDUCE / REMOVE CC IMPACTS

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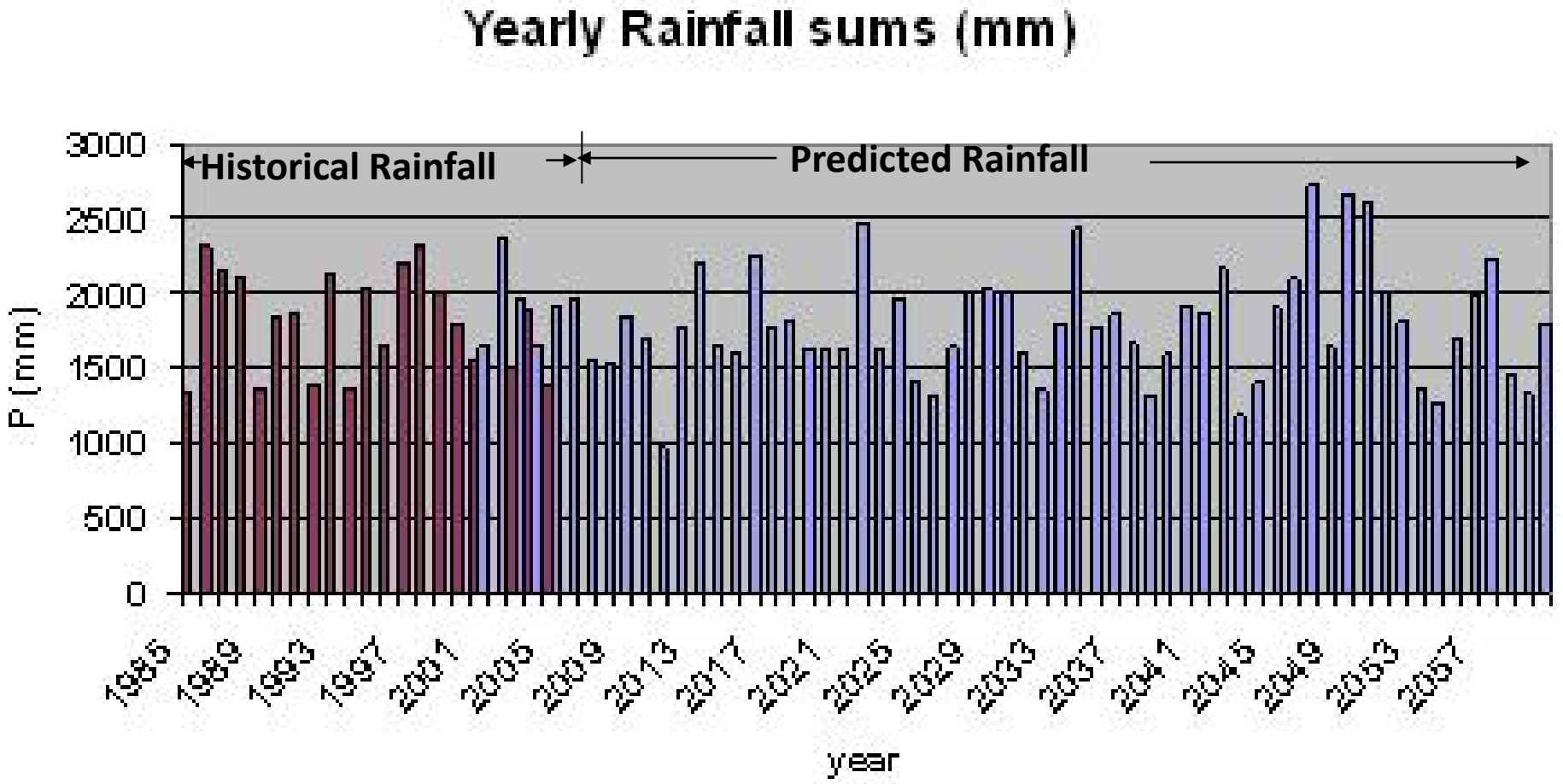
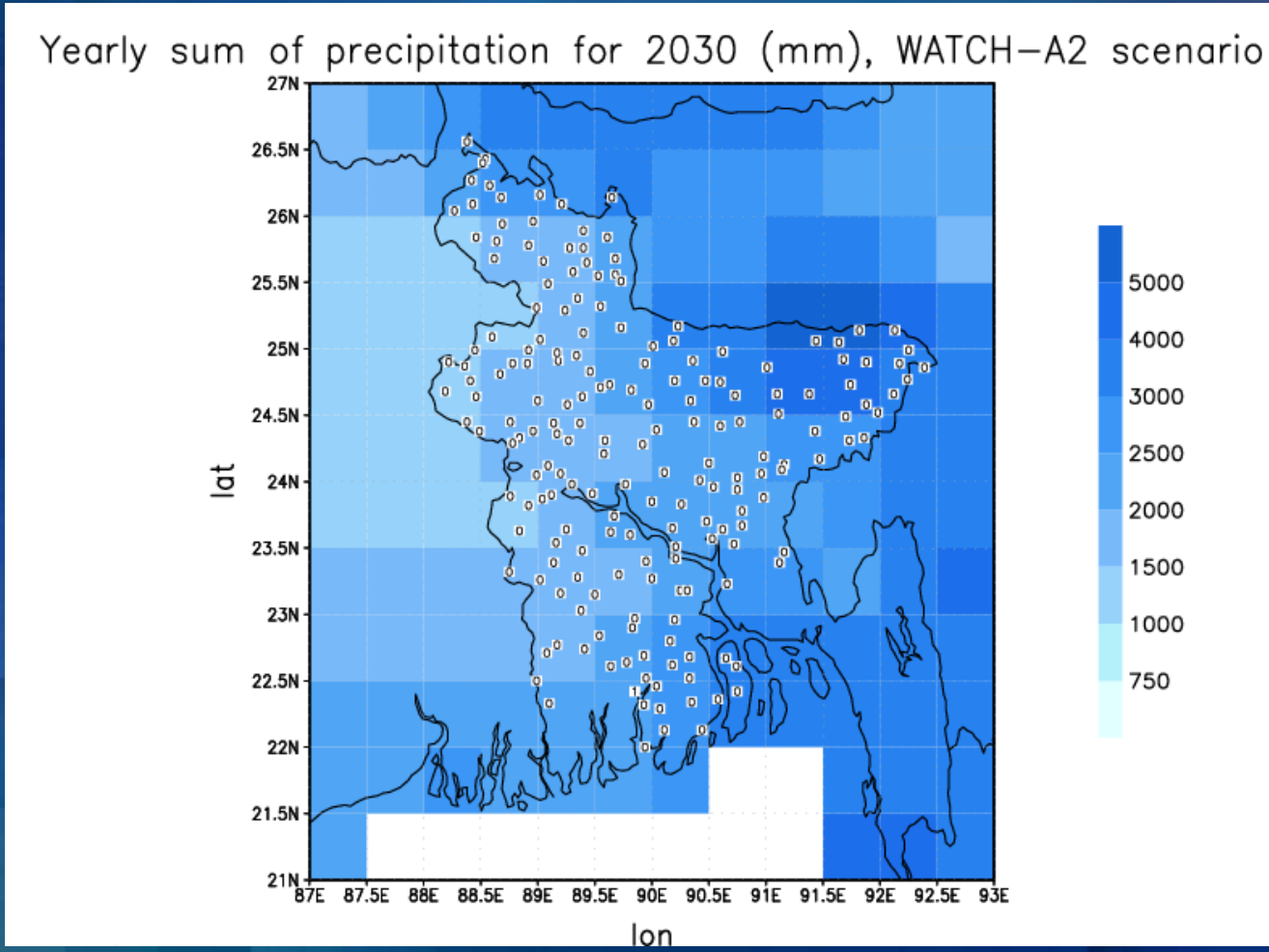
Climate Change Scenarios

Yearly Sum of Rainfall 1985-2060

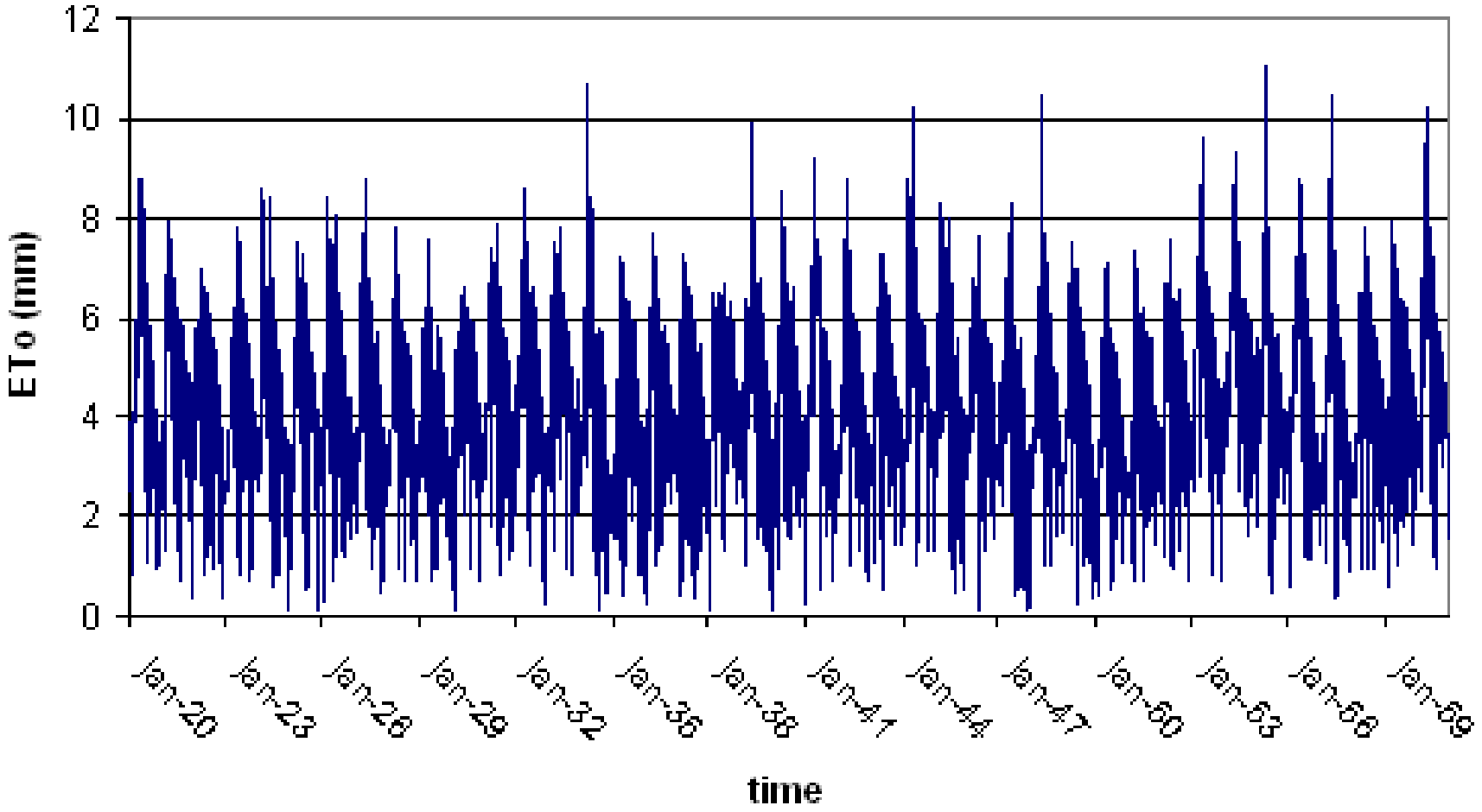


Climate Model

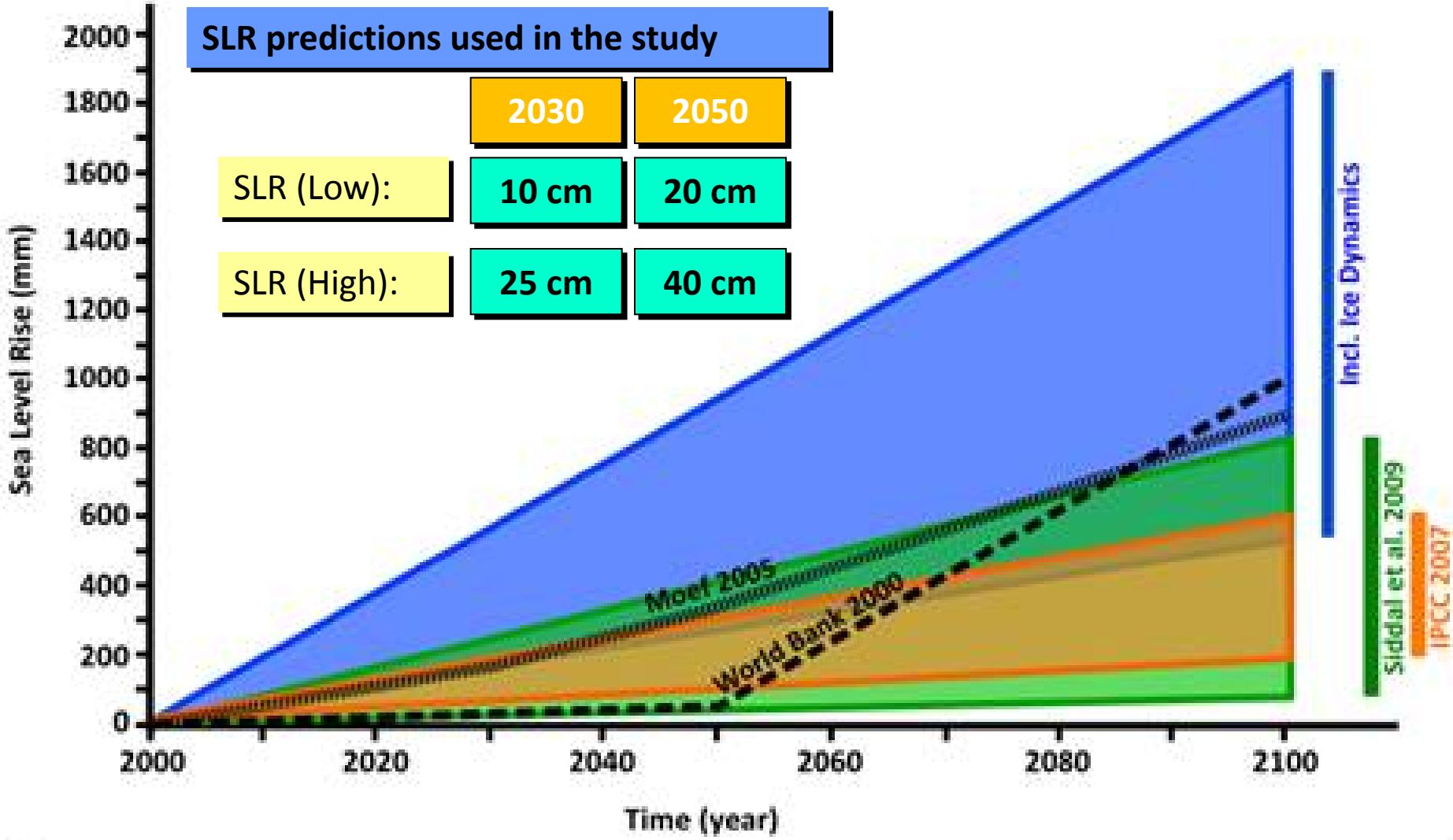
- ECHAM-MPI-OM model
- WATCH Project for down scaling
- 0.5 x 0.5 º grid resolution



Predicted Evapotranspiration in Khulna under CC 2020-2060



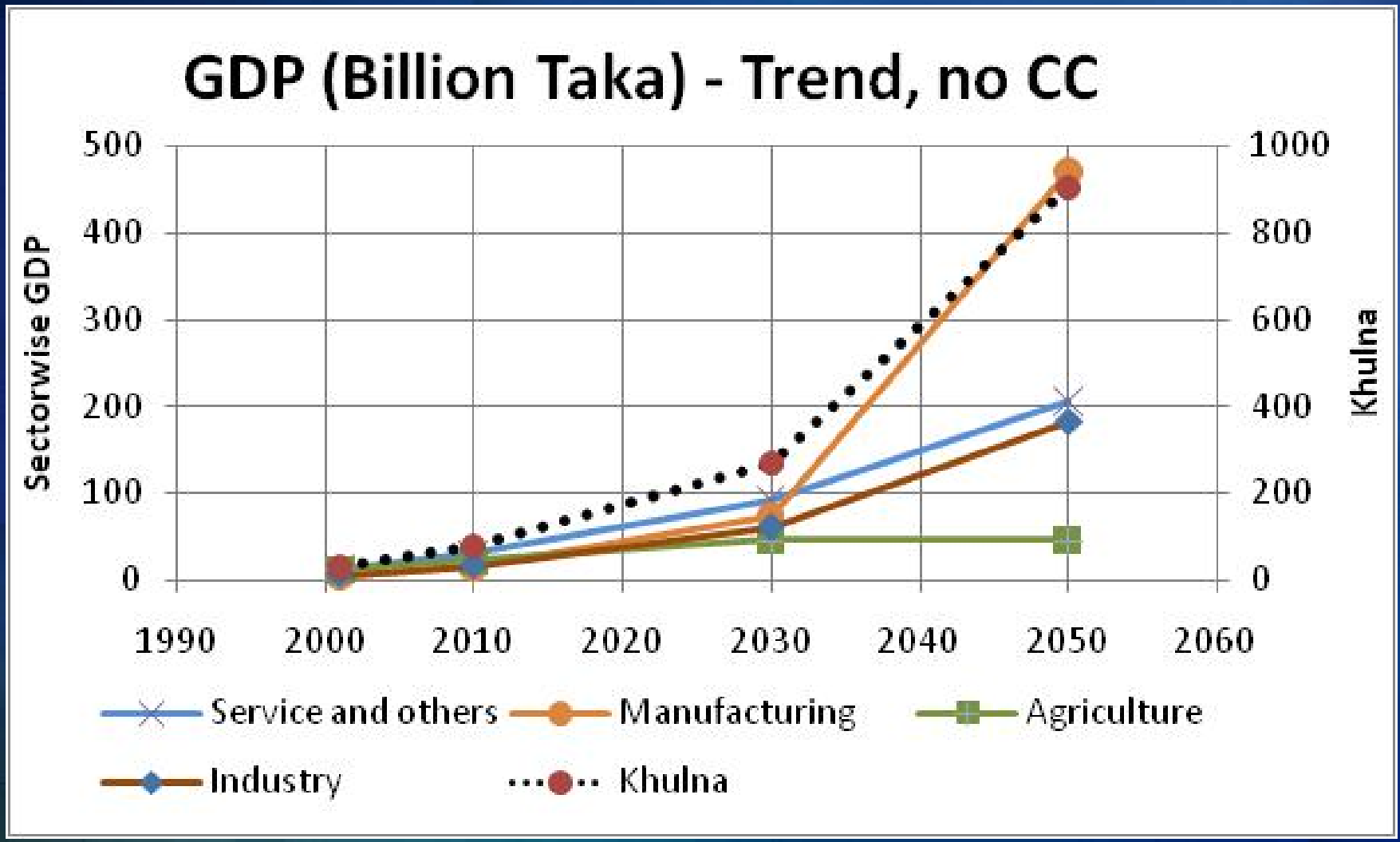
Projected Relative Sea Level Rise in Bangladesh



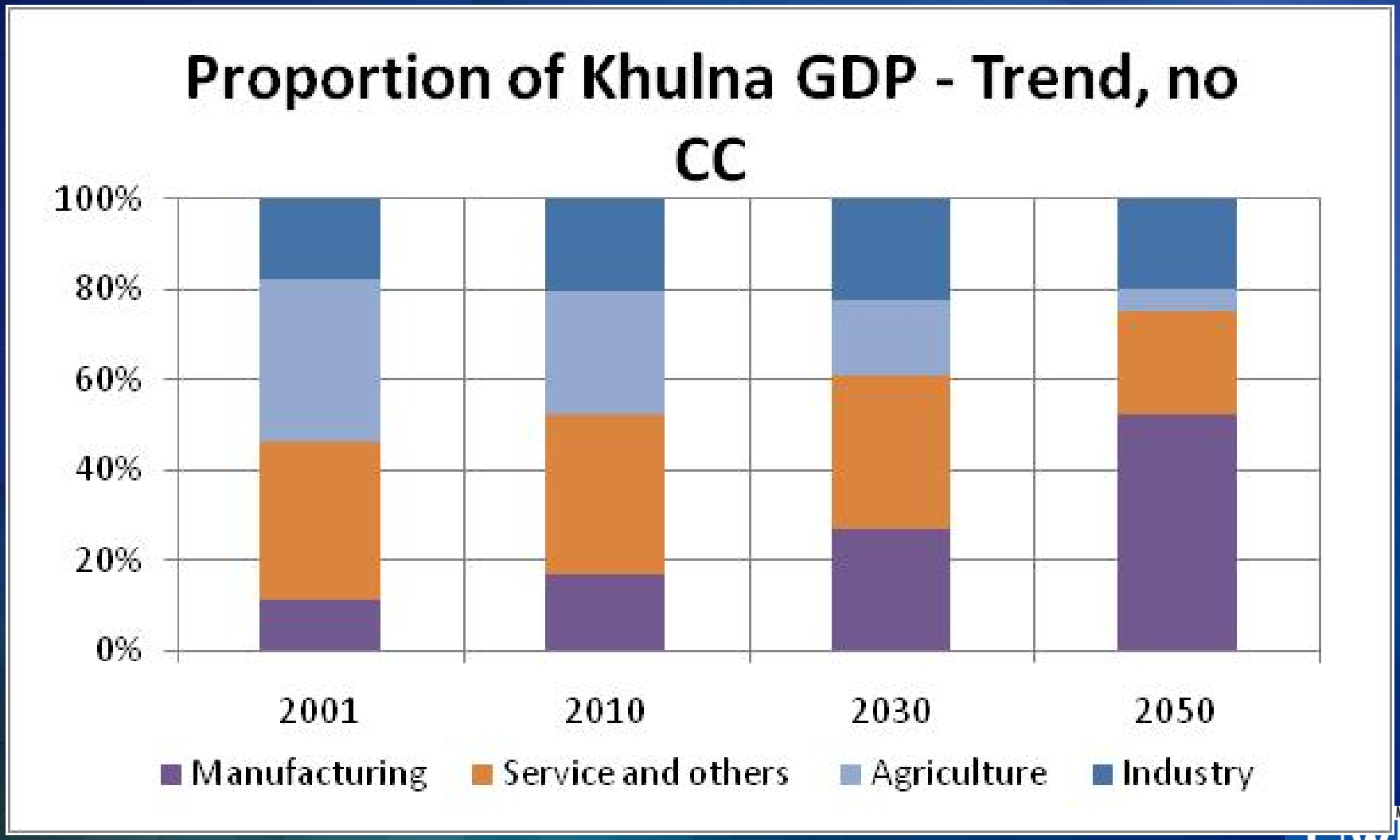
Socio-economic Scenarios

1. Population by ward
2. Water demand (domestic and total)
3. Water supply connections (by % household)
4. Residential building types (by % household)
5. Number of economic enterprises (wholesale/retail, manufacturing and hotel/restaurants)
6. Number of social enterprises (community/social services, education and health)
7. Proportion contribution to GDP of Khulna (manufacturing, agriculture, industry, service/others)

Khulna GDP

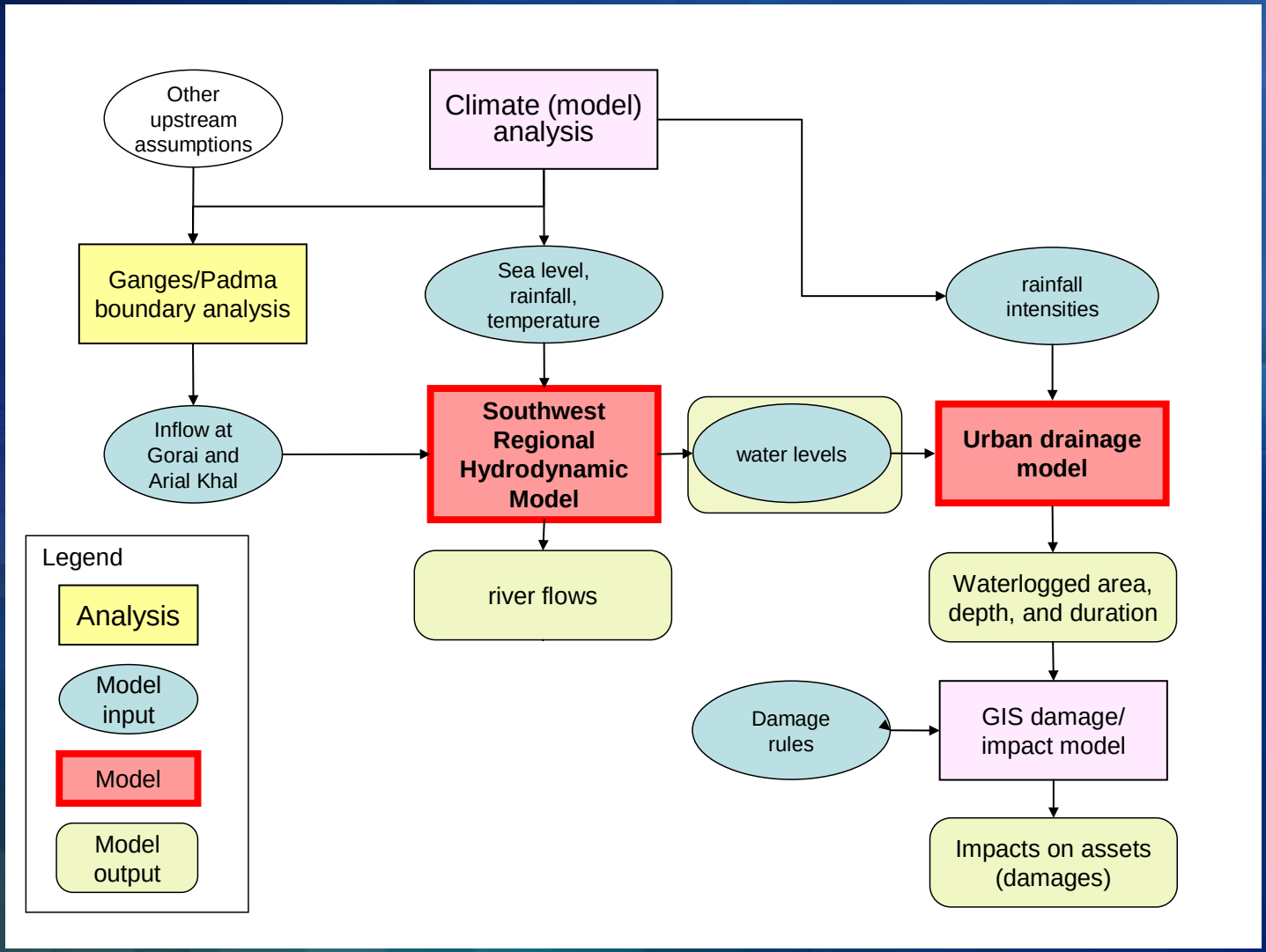

GDP (Billion Taka) - Trend, no CC
Sectorwise GDP
Khulna
500
400
300
200
100
0
1000
800
600
400
200
0
1990
2000
2010
2020
2030
2040
2050
2060
Service and others
Manufacturing
Agriculture
Industry
Khulna

Changes in GDP proportions



Climate change impacts on city drainage and adaptation options

Modeling Framework



Models Used

South West Region Model (SWRM) was used for Flood Modeling.

SWRM covers 26,000 sq km. Developed in 1988 and getting recalibrated and validated every 3 years.

A new Urban Drainage Model (UDM) was developed for the Khulna City

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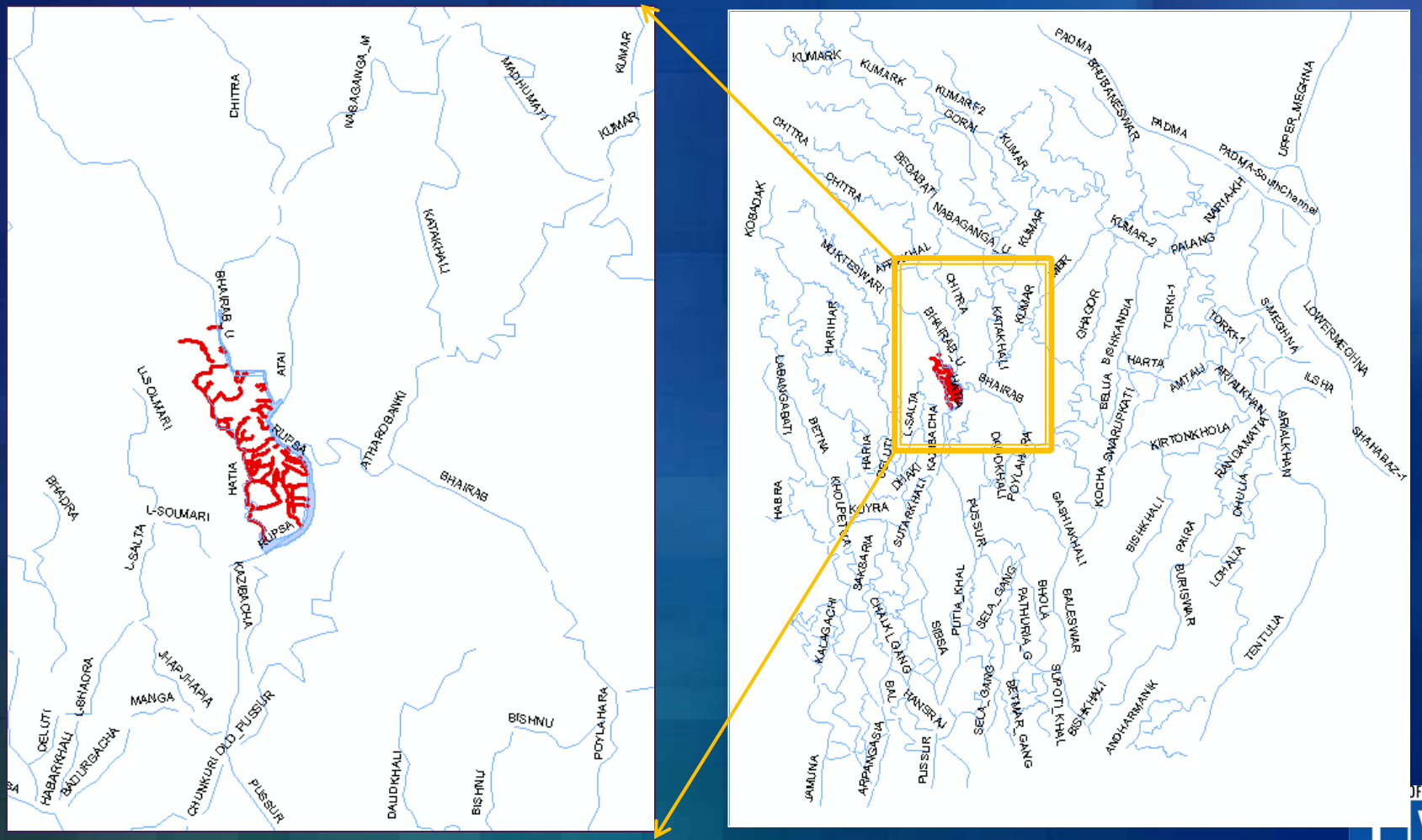
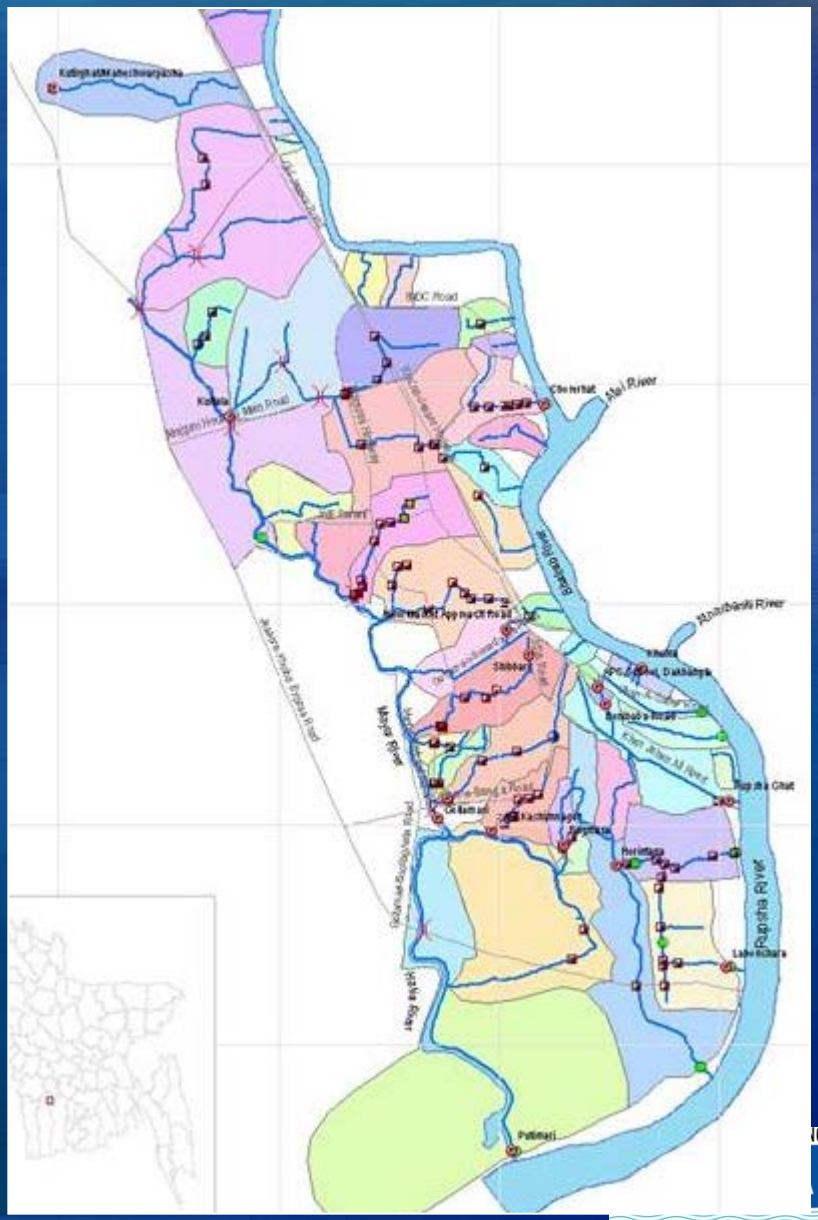
Regional Model



Khulna City Drainage Model

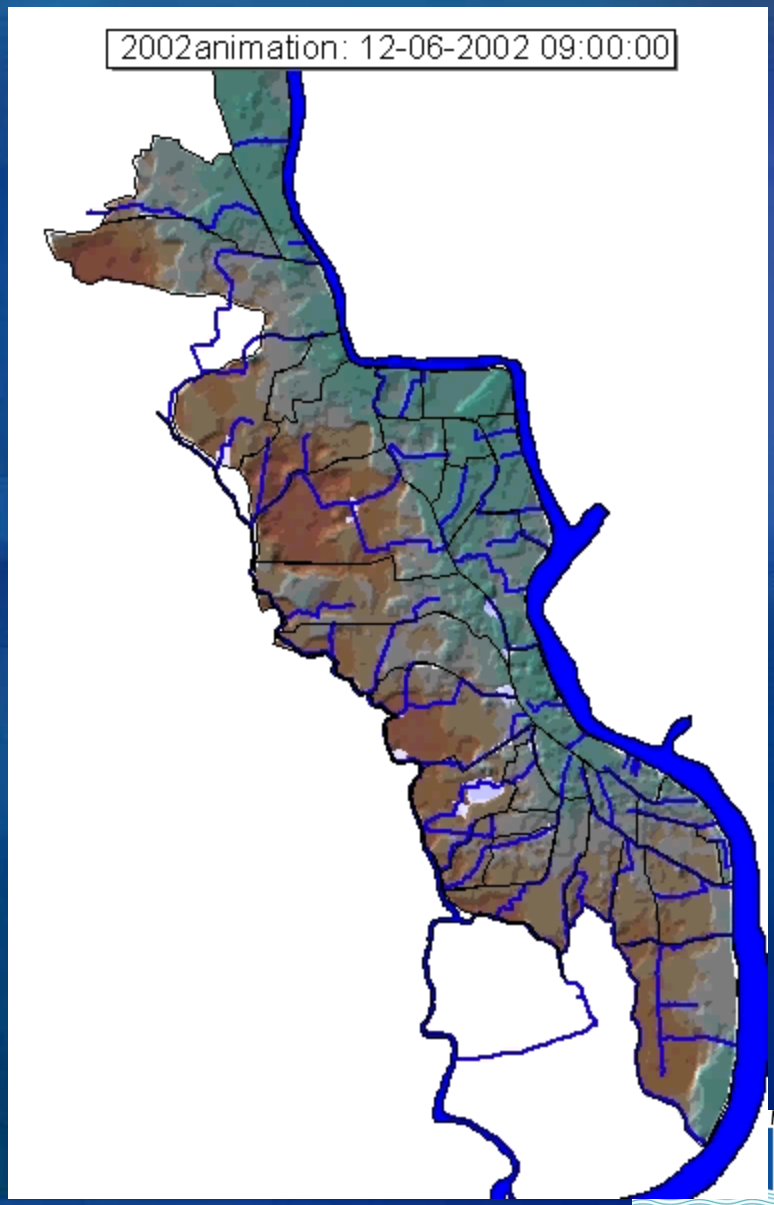
- 100 km of channels
- 400 cross sections
- 54 sub-catchments
- Structures
- Climate change input
  - Increased rainfall intensity
  - Increased outfall water level due to SLR



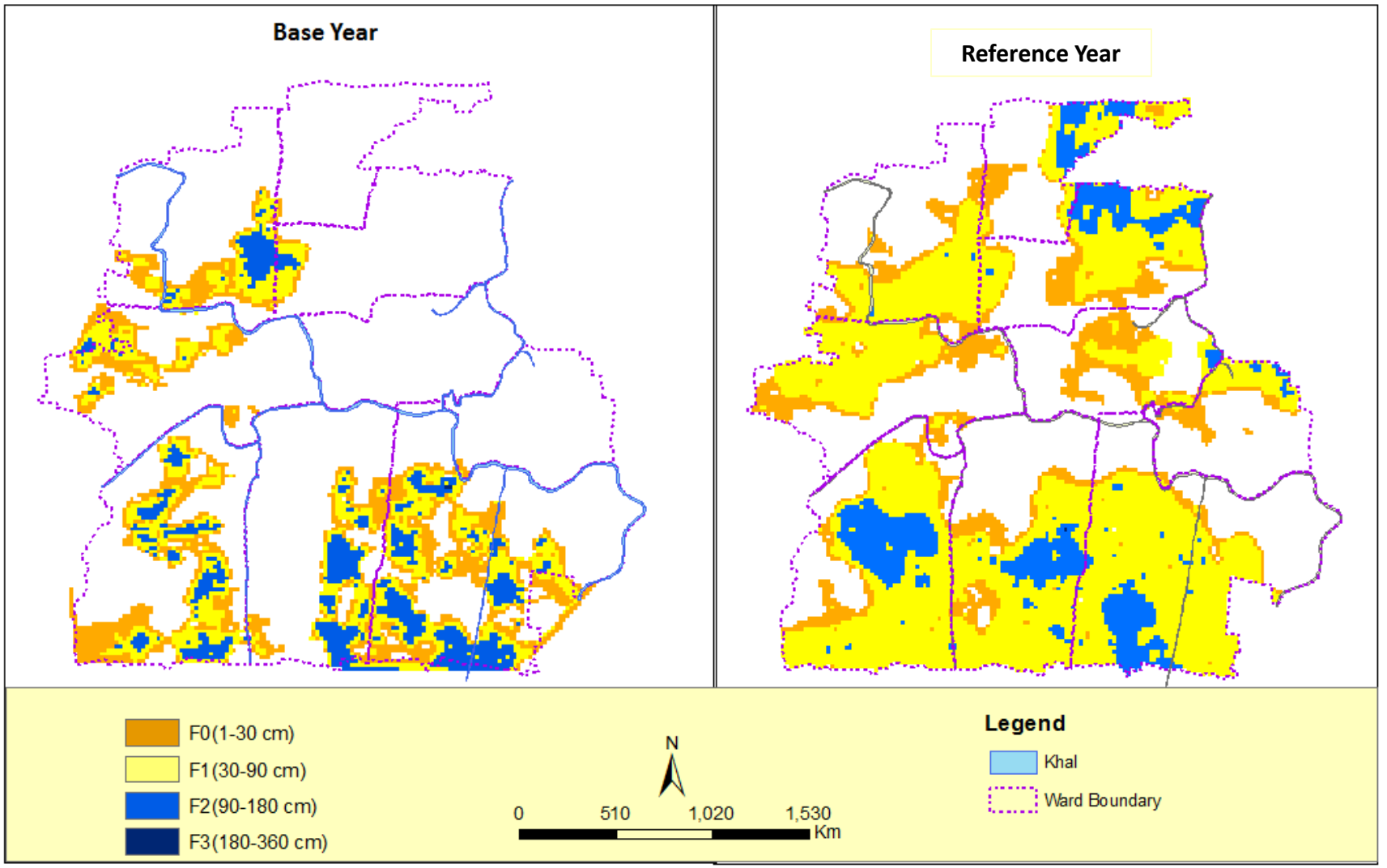
Modelling of Drainage System

- Combination of future scenario: (2030 A2 with High SLR, 2050 B1 with low SLR etc)
- 20 yrs runs were done for SWRM: Base, 2030, 2050
- Results incorporated in KUD
- 20 yr runs for each scenario: base w/out improvement,

  base with improvement, 2050 with adaptation etc.



Inundated Areas



Flooding Impact

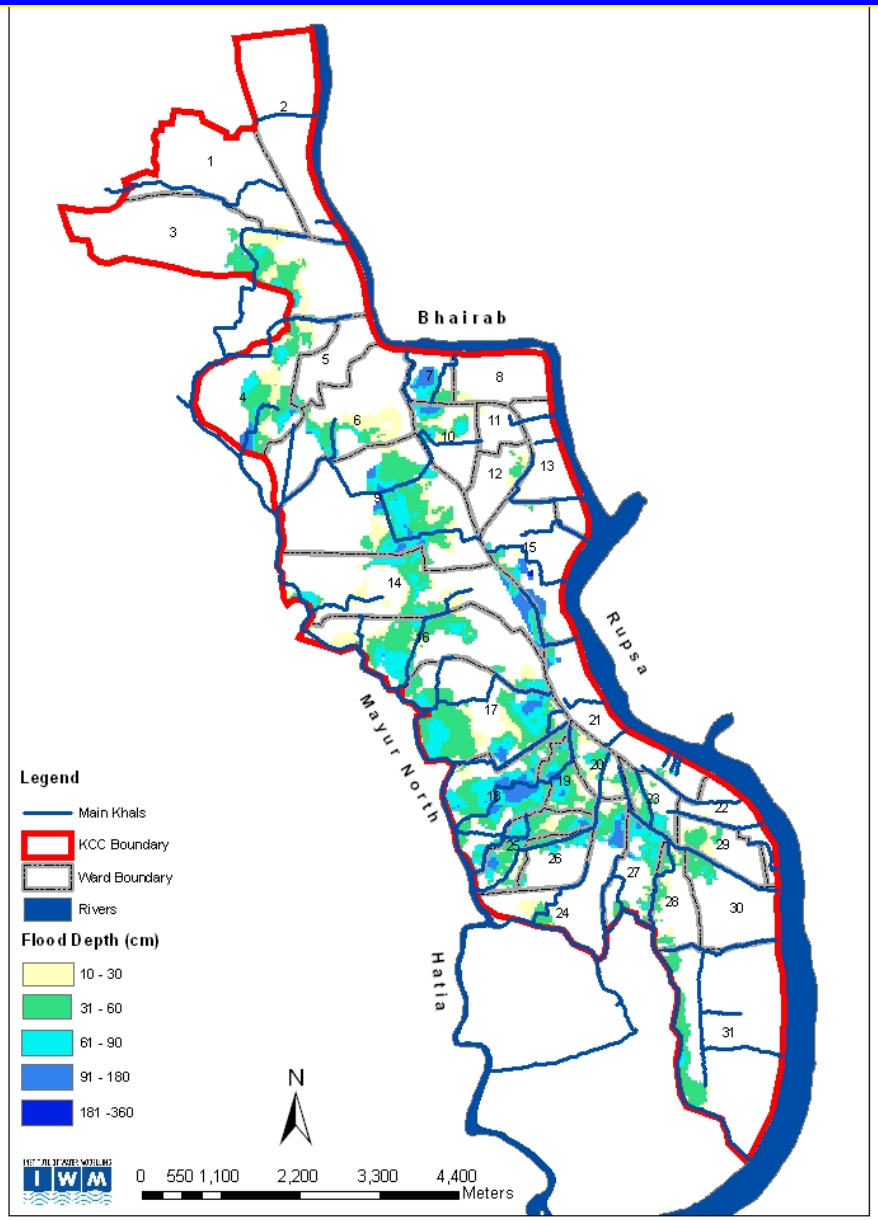
- Percentage of flooded area in the City

Scenarios	FF	F0	F1	F2	F3	Damaging Water Depth
	0 - 10 cm	11- 30 cm	31-60 cm	61-90 cm	91-180 cm	F1+F2+F3
Base 10 yr	64	7	26	3	0	29
Base 5-yr	81	7	11	1	0	11
2030-10yr	60	7	28	5	0	34
2030-5yr	71	8	19	2	0	21
2050-10yr	42	3	23	28	3	54
2050-5yr	58	10	28	4	0	32

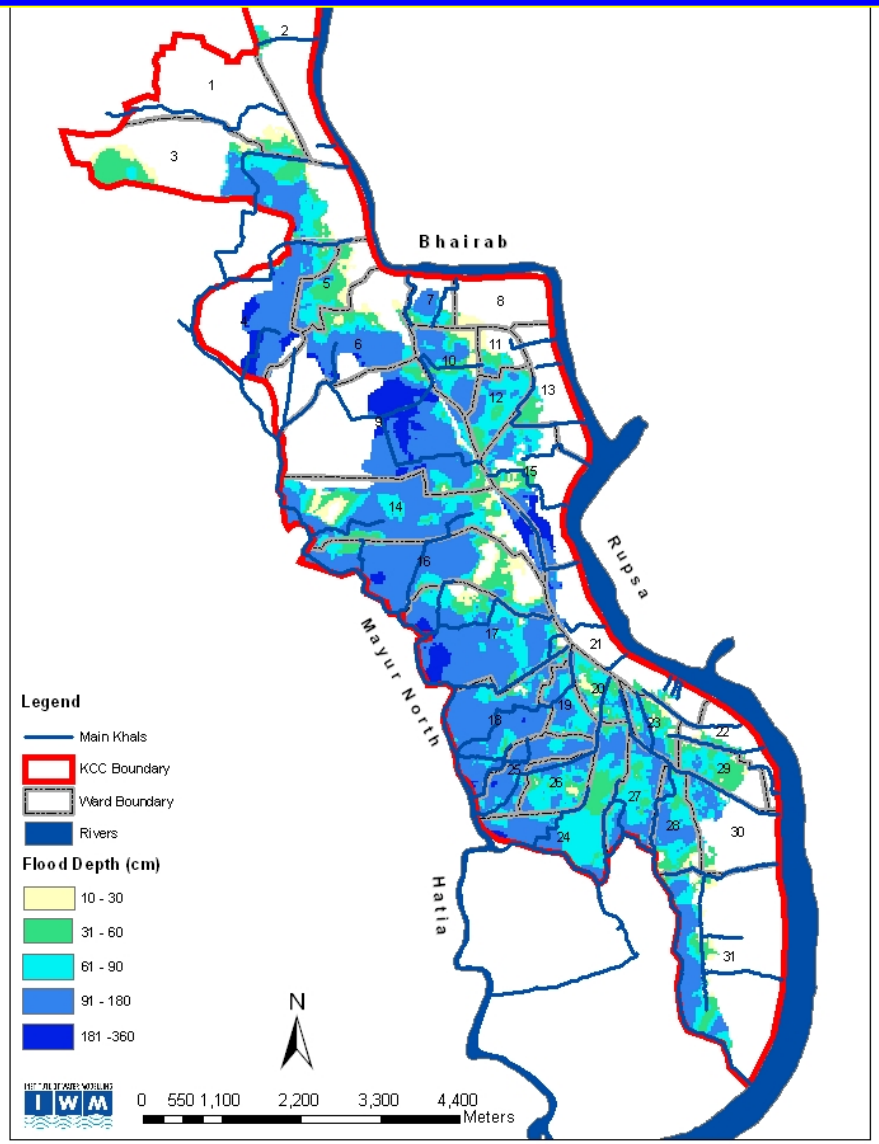
Adaptation Options

- Khulna urban drainage
  - Core options
    - Widen/deepen drains
    - Lay new drains
    - River dredging
    - Sluice gate
  - Add-on options
    - Good solid waste management
    - Awareness and education campaigns
    - Introduce drainage tax
    - Strict implementation of fines and planning measures
    - Improved prediction and early warning system

Base: Do nothing scenario



2050: Do nothing scenario
With climate change



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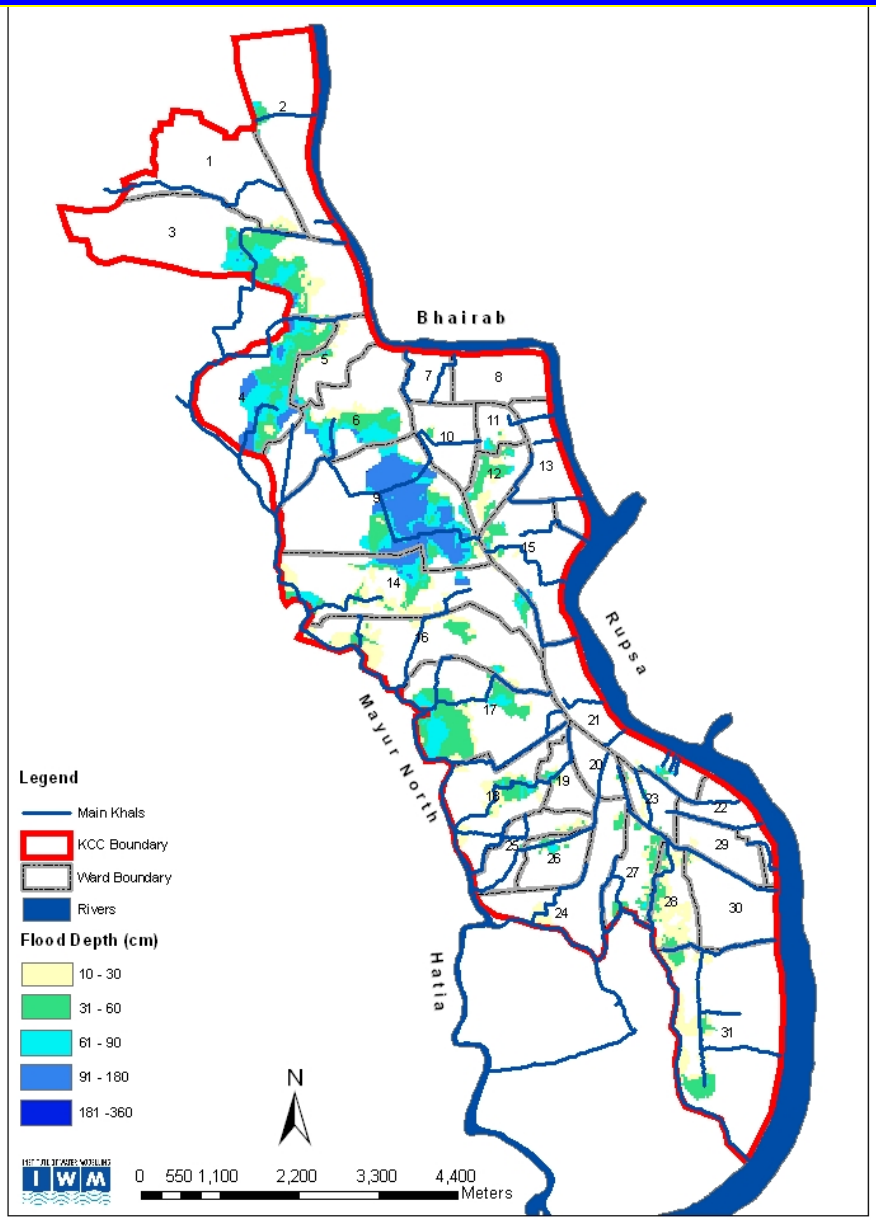
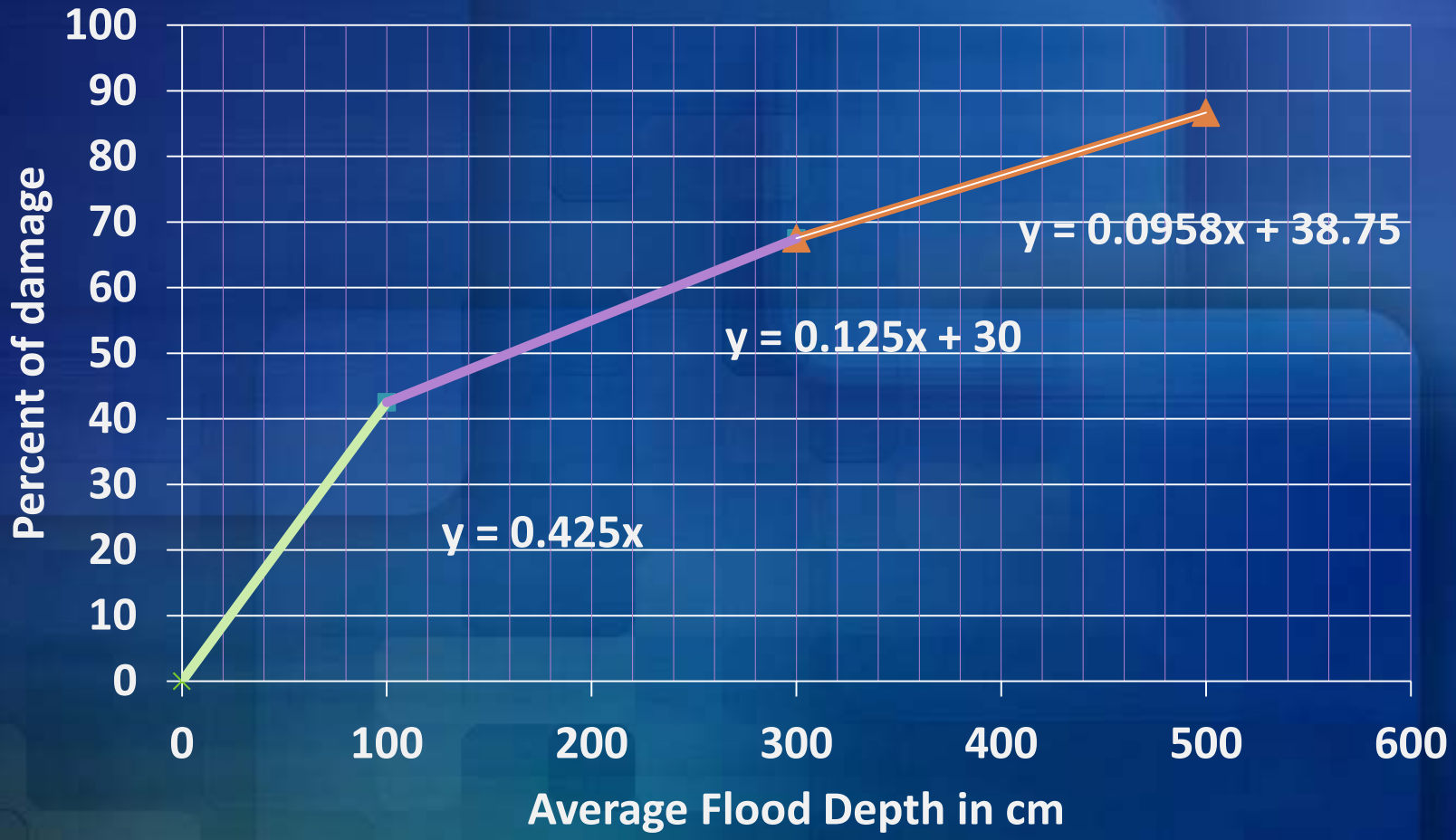
2050: with CC, adaptation options



Evaluation Framework

- Social
  - Number of people affected (+/-)
  - Public acceptance
  - Resettlement requirement
  - Overall health impact
- Economic
  - Investment costs
  - Operating and maintenance costs
  - Damage costs and benefits

Damage function - manufacturing



Impact of Climate Change and Impact of Adoption of Adaptation Strategies

KCC Area	Average flood depth (cm)	% Asset of Household	% of Capital Industry	% of Capital in Manufactu-ring	% of Capital in Commerical & Others	% of Agriculture Yield	% of Road length nneedsrepair	% Affected Population
Base+do nothing	41	16	15	18	19	19	15	24
Base+Imprvd DS	33	13.3	12.1	14.1	14.9	15.2	12.1	6
2050+SE+Imprvd DS	33	13.3	12.1	14.1	14.9	15.2	12.1	6
2050+SE+CC+ do nothing	63	21.5	22.9	26.6	28.1	28.7	22.9	58
2050+SE+CC + Imprvd DS	47	18	17	20	21	22	17	30
2050+SE+Imprvd DS+CC+AS1	40	16	15	17	18	19	15	13

NET BENEFIT FROM CLIMATE PROOFING OF THE PROJECT

KCC Area	avge flood depth (cm)	Household	Industry	Manufacturing	Commerical & Others	Agriculture	Roads	% Population
Benefit of Base Improved DS	8	3	3	4	4	4	3	18
CC Impact 2050	14	5	5	6	6	6	5	24
Impact of AS1	7	2	2	3	3	3	2	18

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Conclusion

- Climate change should be given adequate consideration in urban drainage design and planning
- Models are useful to understand the impact of climate change
- In the Khulna study it was possible to quantify the benefit of adaptation measures


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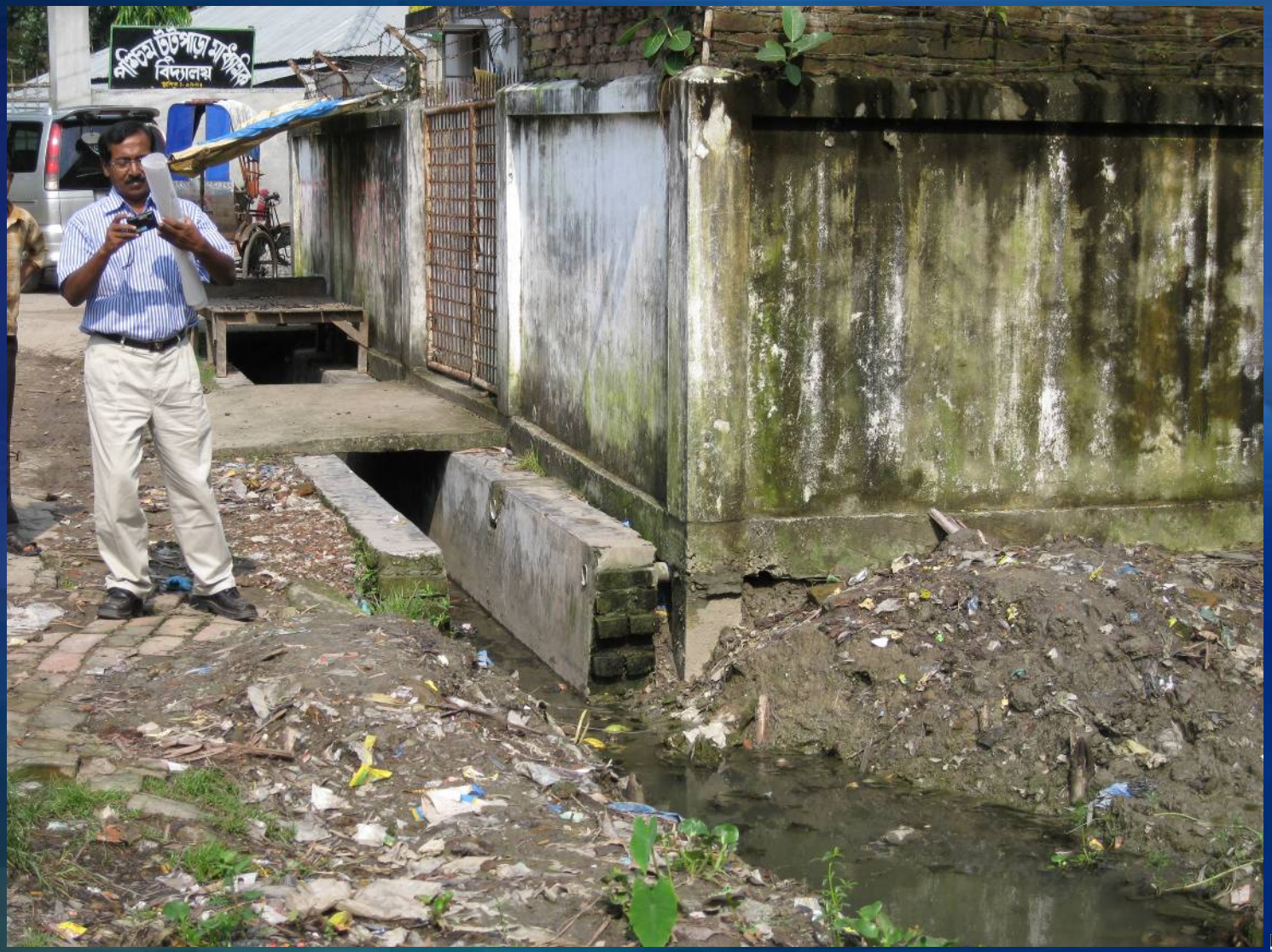

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THANK YOU

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