ASEAN Academic Networking in Water, Disaster Management and Climate Change

HYDROCLIMATE PROJECTIONS TO ENGINEERING PRACTICES FOR ADAPTATION MEASURES IN WATER RESOURCES SECTOR

Research Centre for Water Resources and Climate Change
National Hydraulic Research Institute of Malaysia
Ministry of Natural Resources & Environment

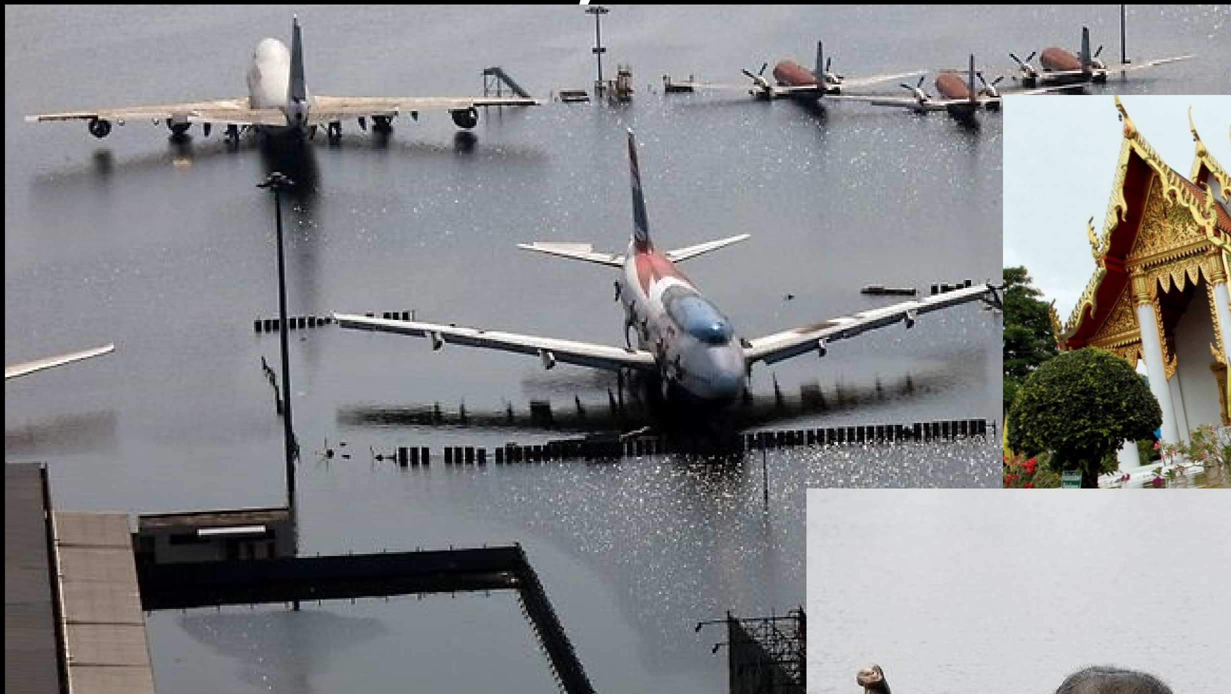
28 January 2015

Bangkok, Thailand

OUTLINE

1. WATER MANAGEMENT ISSUES & CHALLENGE
2. LINKAGES OF CLIMATE & NON-CLIMATE FORCING
3. KNOWLEDGE PATHWAYS TO ENGINEERING PRACTICES
4. KNOWLEDGE PATHWAYS TO ADAPTATION POLICIES

Thailand Floods, Jul 2011-Jan 2012..

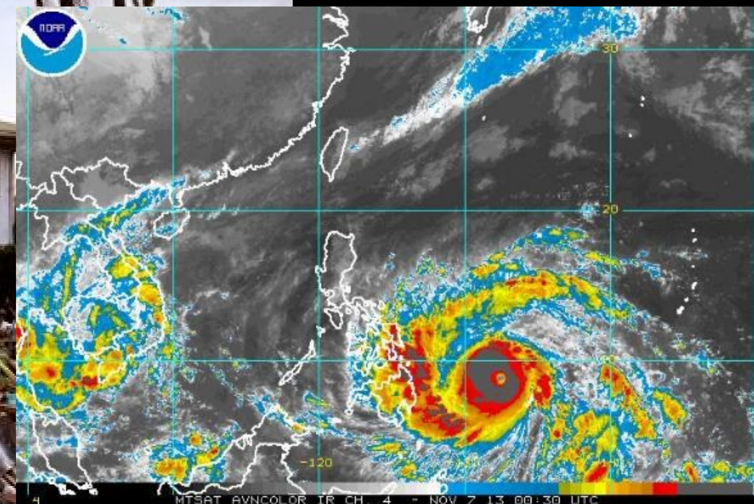


Thailand's worst flooding in 50 years..
Estimated economic loss > USD45 billion..
13.6 million affected..
>800 deaths..

Jakarta Floods, Jan 2013..

Estimated economic losses USD3.3billion…
320,000 people displaced..
>40 deaths..

Typhoon Haiyan, Philippines, Nov 8 2013..



4.1 million without homes..
5.9 million workers lost income sources..
1,785 missing..
6,200 deaths..

Pakistan Floods, Sept 2014..

Worst flood in Pakistan history..
2.5 million affected..
367 deaths..

Mudflood in Cameron Highland, Malaysia Oct 23, 2013 & Nov 5, 2014..

Dam release due to heavy downpour & upstream flooding..

> 80 houses destroyed..

6 deaths..

Kelantan Floods, Malaysia Dec 14-24, 2014..

Continuous heavy downpour & upstream flooding..

> many properties & infrastructures destroyed..

25 deaths..

……water management issues….

water excesses, **water shortages, water pollution**

..due to non-climatic & climatic forcing…

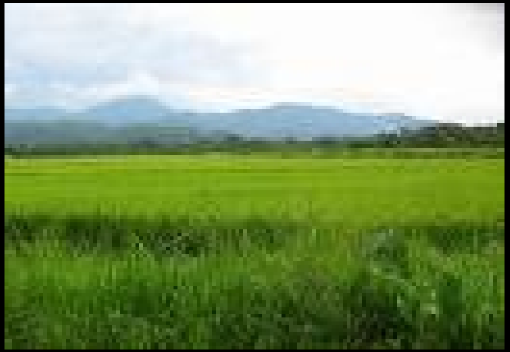
….be more complicated in water sector due to……

Source: SREX Report (IPCC, 2011)

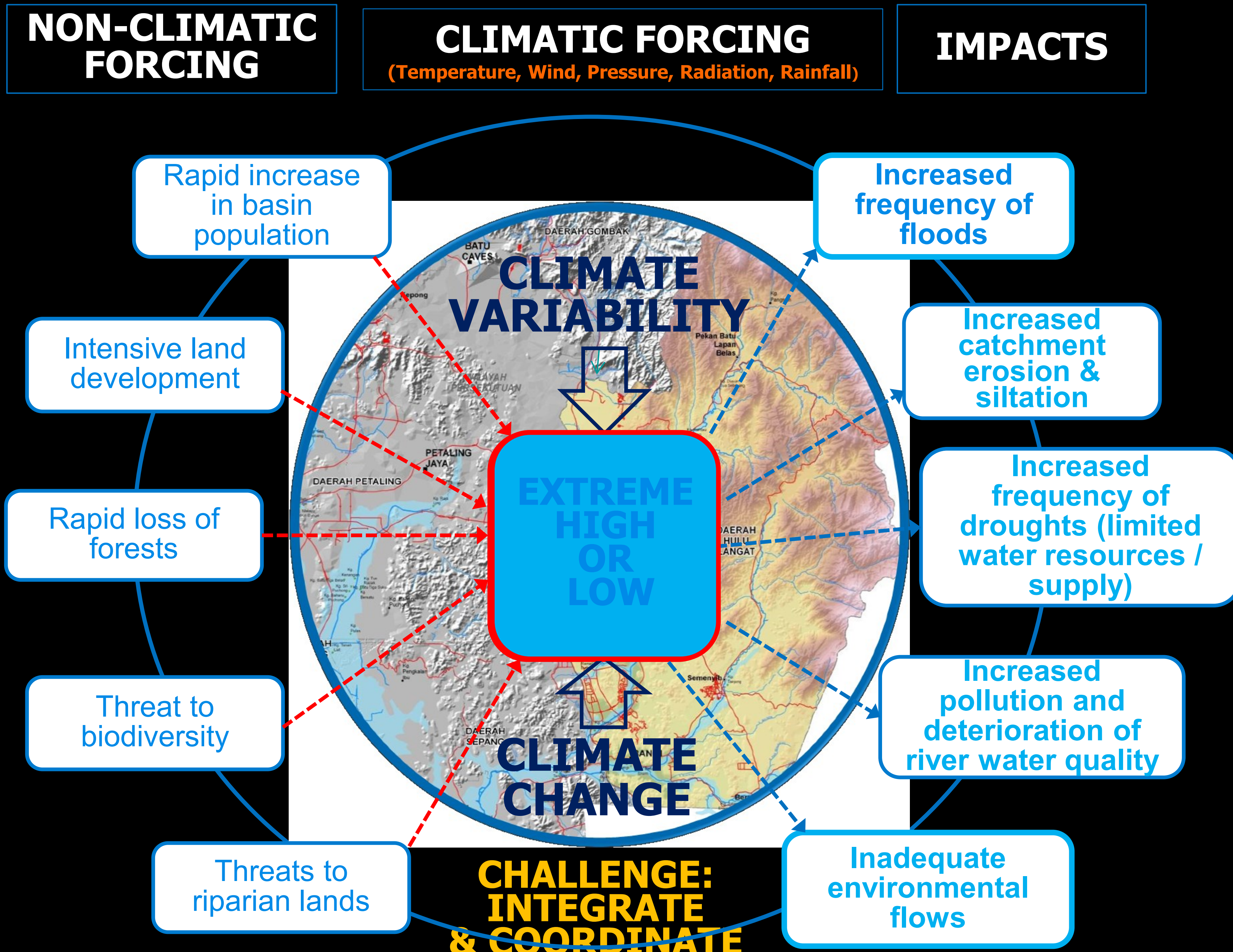
a changing climate leads to change in extreme weather and climate events would contribute to water related disaster (water excess)

Water managers & climate change

- two major challenges in a changing climate:
  - How to integrate & coordinate issues of non-climatic and climatic forcing
  - How to build resilience or adapt to climate change impacts
- Acting with the knowledge of climate change scientific findings which are
  - Uncertainty over timing, nature, magnitude of change
  - Costs and benefits difficult to calculate



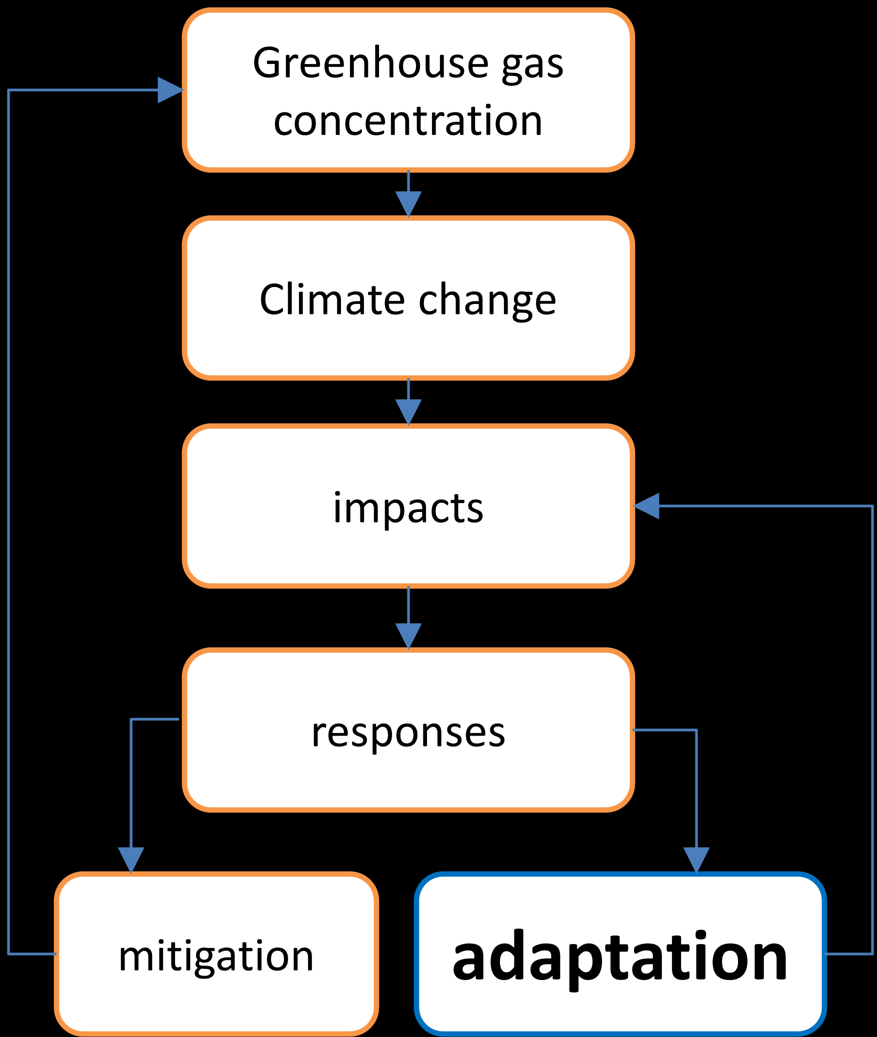
.....linkages of climate & non-climate forcing.....


NON-CLIMATIC FORCING
CLIMATIC FORCING
(Temperature, Wind, Pressure, Radiation, Rainfall)
IMPACTS
Rapid increase in basin population
Intensive land development
Rapid loss of forests
Threat to biodiversity
Threats to riparian lands
CLIMATE VARIABILITY
EXTREME HIGH OR LOW
CLIMATE CHANGE
Increased frequency of floods
Increased catchment erosion & siltation
Increased frequency of droughts (limited water resources / supply)
Increased pollution and deterioration of river water quality
Inadequate environmental flows
CHALLENGE: INTEGRATE & COORDINATE

…..and **increasing exposure** of people and assets would be the major cause of changes in disaster losses…..

…..but how we can **"cushion" this impacts** (climate and non-climate forcing)…?

.....through mitigation & adaptation processes

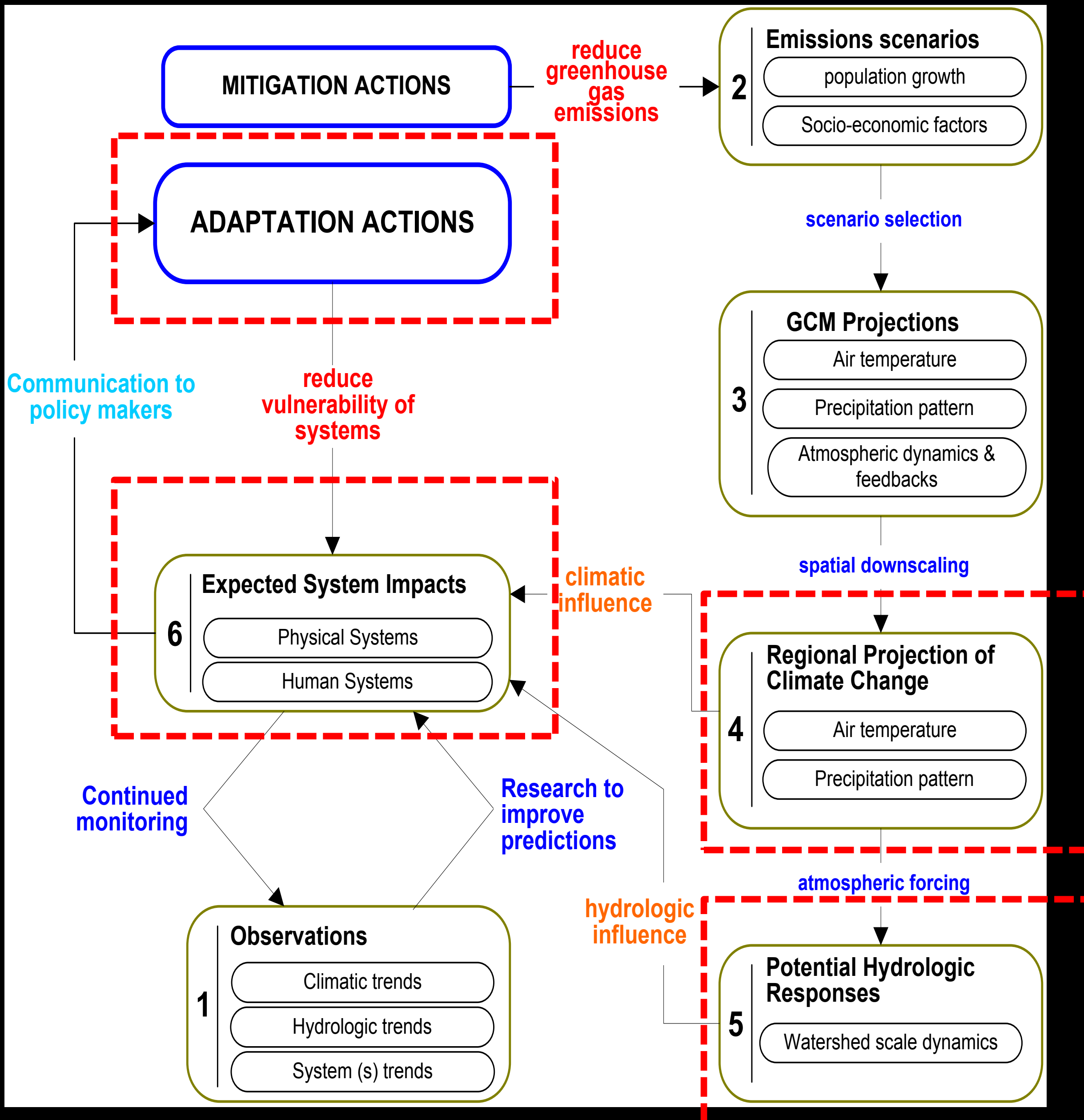


Intervention to reduce the emmision sources

an adjustment in natural or human system systems in response to actual or expected climatic stimuli or their effects

- ❑ Primarily a **local issue** as adaptation mostly provides benefits at the local scale
- ❑ Adaptation can have a **short-term effect** on the reduction of vulnerability
- ❑ Adaptation is **a priority in the water sectors** as well as in health and coastal sectors

ADAPTATION & VULNERABILITY IMPACT ASSESSMENT



pro-active adaptive management – water infra with buffering capacity, robustness & resilience to climate change & variability

Impacts & vulnerability assessment

Water supply, floods, ecosystem, infrastructure, road, etc

Adaptation options & measures

CLIMATIC DRIVEN FACTOR

NON-CLIMATIC DRIVEN FACTOR

….pathways of engineering practices and adaptation processes……

.....how it can be done? ...develop climate knowledge base & bridge the gap of science, engineering & socio-economics ......

.....pathways from knowledge to adaptation practices......

Source: X. Wang, CSIRO 2012

….develop climate change knowledge & capacity building…….

…pre-requisite to have knowledge in climate change modeling and projection…..

- Impacts of Climate Change on Hydrologic Regimes and Water Resources for Peninsular Malaysia (NAHRIM, 2006)
- Impacts of Climate Change on Hydrologic Regimes, Water Resources and Landuse Change for Sabah & Sarawak (NAHRIM, 2010)
- Climate Projection Downscaling for Malaysia Using Hadley Centre PRECIS Model (NAHRIM,2010)
- Impacts of Sea Level Rise (SLR) for Malaysia (NAHRIM, 2010)
- Extension of the Study of the Impact of Climate Change on the Hydrologic Regime and Water Resources of Peninsular Malaysia (NAHRIM, 2014)

FUTURE HYDRO-CLIMATE DATA BASE

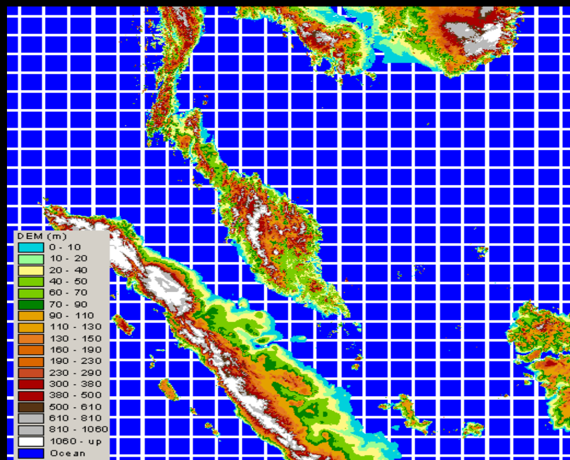
		Type of Projected Hydroclimate Data					
Data Resolution	**Mode of Data type**	**Temp.**	**Rainfall**	**Flow**	**Runoff**	**Evapo-transpiration**	**Soil Water Storage**
Daily		√	√	√	√	√	√
Monthly	Total						
	Mean						
	Minimum						
	Maximum						
Anually	Total						
	Mean	√					√
Maximum	1-day						
	2-day						
	3-day						
	5-day						
	7-day						

.....water resources-supply availability & drought assessment...

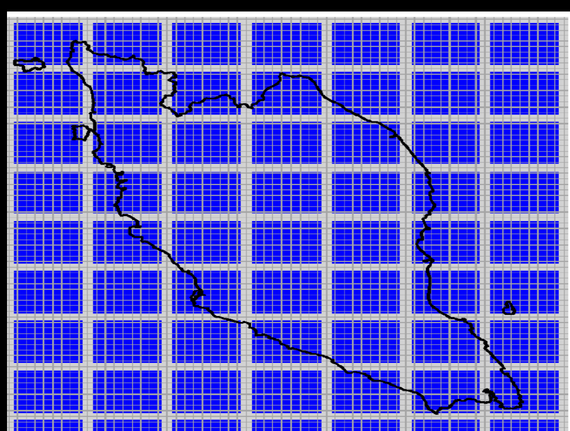
.....floods assessment, planning and design....

http:www.futurehydroclimate.nahrim.gov.my

…revisit climate change modeling and projection for Peninsular Malaysia…..



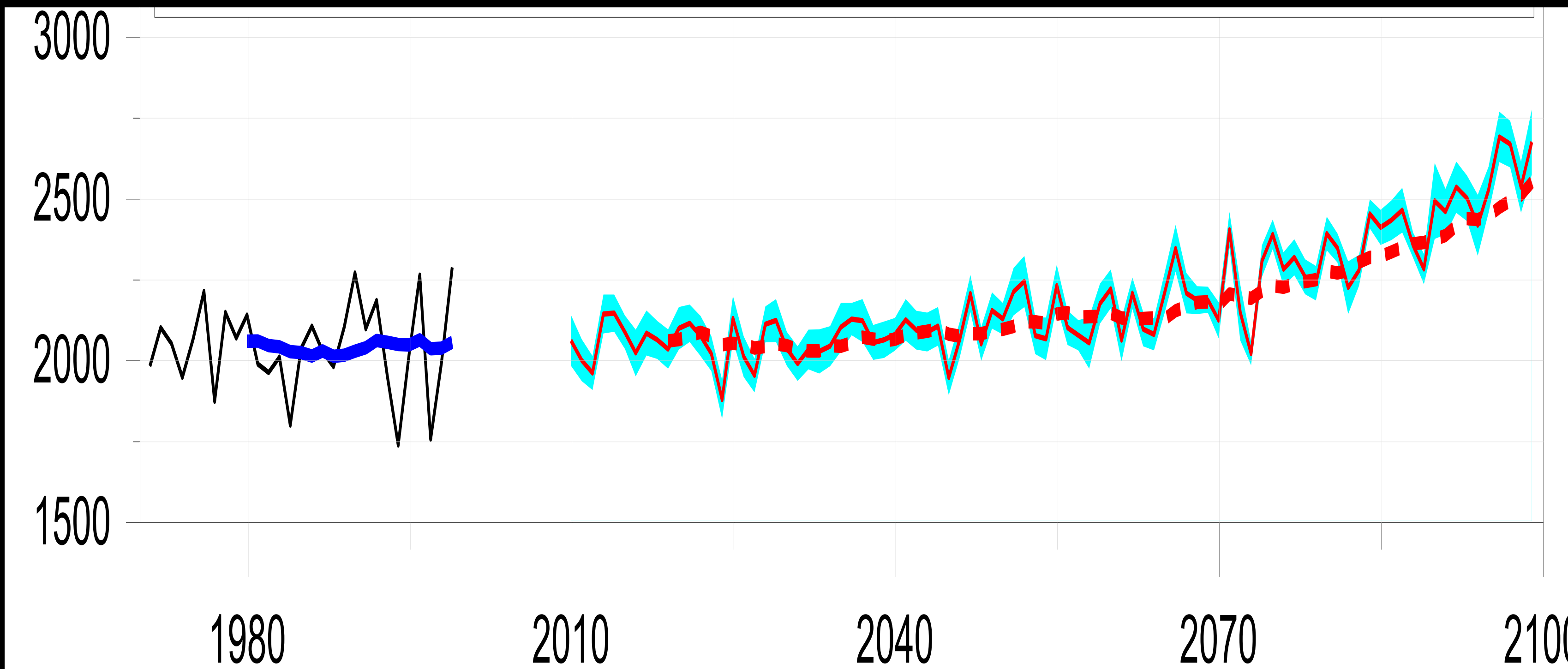
18km x 18km



6km x 6km

- **2006 - Downscaling** Canadian GCM1 (~ 410km resolution), to **fine spatial resolution** (~9km)
- **Extention study**:
  - **3 GCMs** – MPI-ECHAM5, CCSM3 and MRI-CGCM2.3.2
  - **15 scenarios** – SRES A1B (5), B1 (5), A2 (1) and A1Fi (1)
  - Downscaling GCMs (~150-310km) to watershed scale **spatial resolution of 6km**
  - **Hourly** time interval resolution
  - Completed in July 2014)

....climate change in Malaysia....



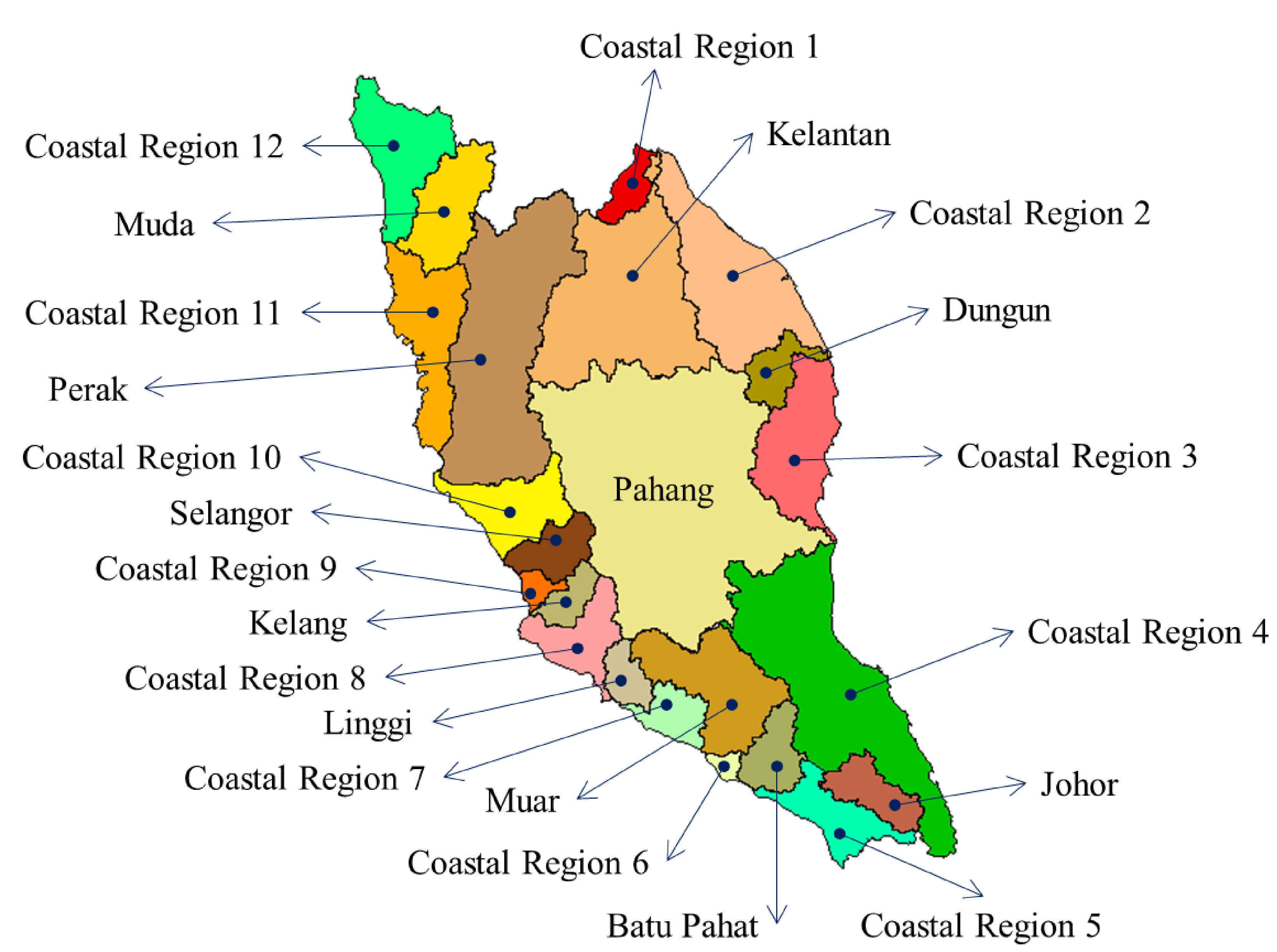
↑
WET

10-yr Avg.
(1970 – 1980)

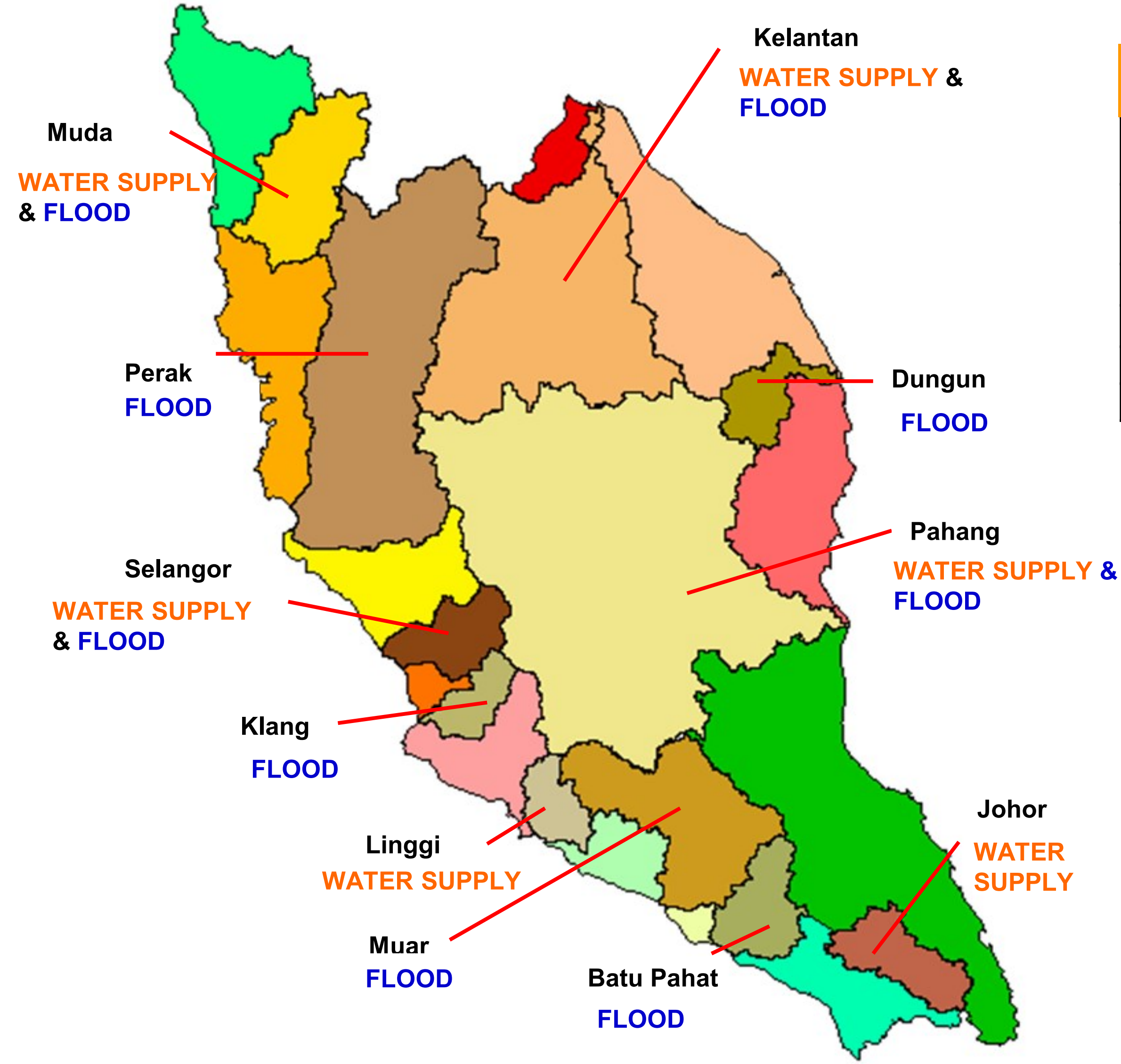
10-yr Avg.
(1980 – 1990)

10-yr Avg.
(1990 – 2000)

…impacts assessment for 11 watersheds & 12 coastal regions…..



Projected High and Low Flows by 2100 – Peninsular Malaysia (NAHRIM, 2014)



Low Flow (m^3/s)

Watershed	2010-2100	1970-2000*	Rate of change
Muda	7.5	14.5	-48%
Selangor	117.7	12.2	-4%
Kelantan	52.3	92.7	-44%
Pahang	27.2	53.6	-49%
Johor	25.3	32.9	-23%
Linggi	1.0	2.6	-62%

High Flow (m^3/s)

Watershed	2010-2100	1970-2000*	Rate of Change
Muda	2702	509	+430%
Perak	9937	2658	+274%
Selangor	1195	583	+108%
Klang	319	148	+115%
Kelantan	10115	40875	+147%
Dungun	671	414.9	+62%
Pahang	4561	2748	+66%
Muar	2630	401	+556%
Batu Pahat	283.2	101	+180%

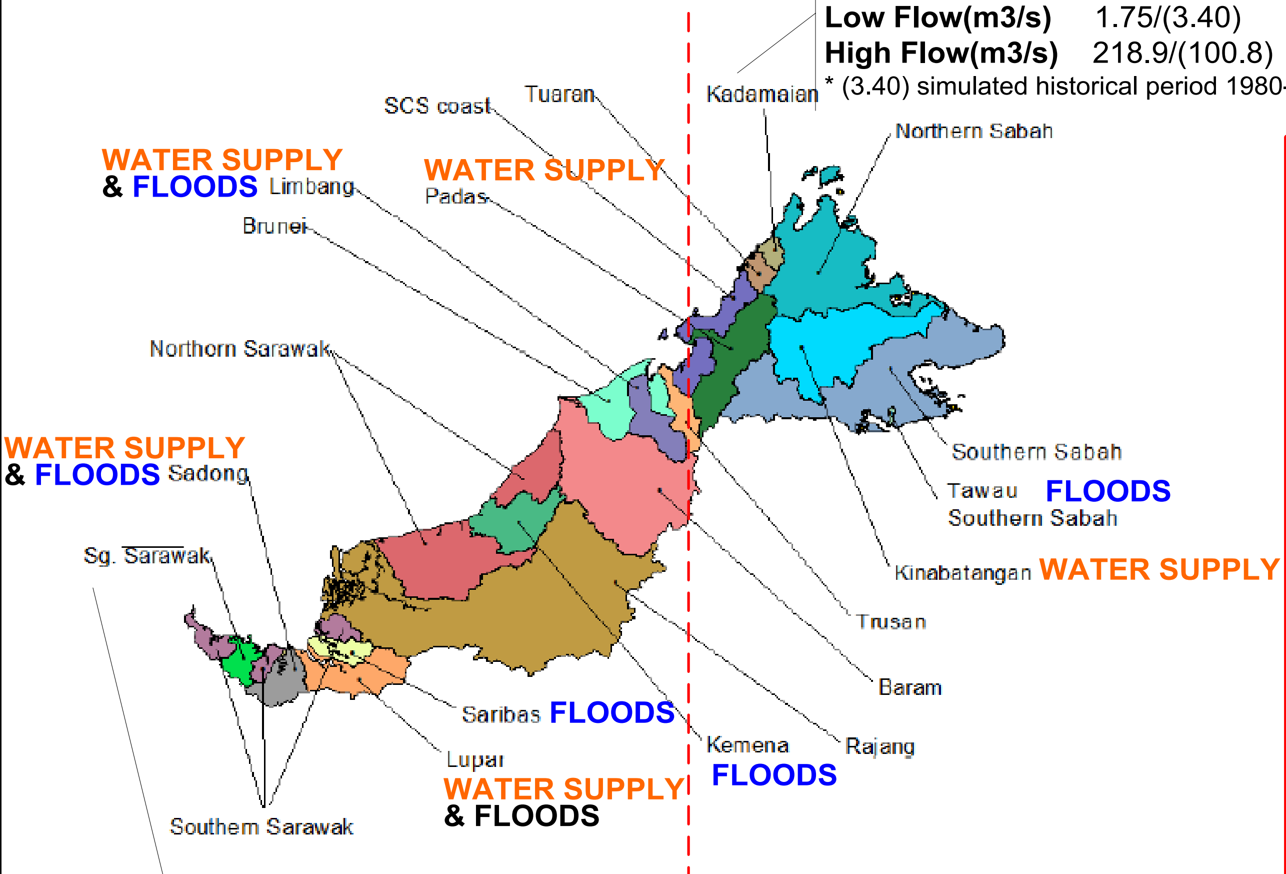
Note: 1970-2000* - simulated historical period

Projected High and Low Flows by 2100 – Sabah & Sarawak

KEDAMAIAN (WATER SUPPLY & FLOODS)

	2040-2050	2090-2100
Low Flow(m3/s)	1.75/(3.40)	3.18/(3.40)
High Flow(m3/s)	218.9/(100.8)	148.4/(100.80)

* (3.40) simulated historical period 1980-2000



SARAWAK R. (FLOODS)

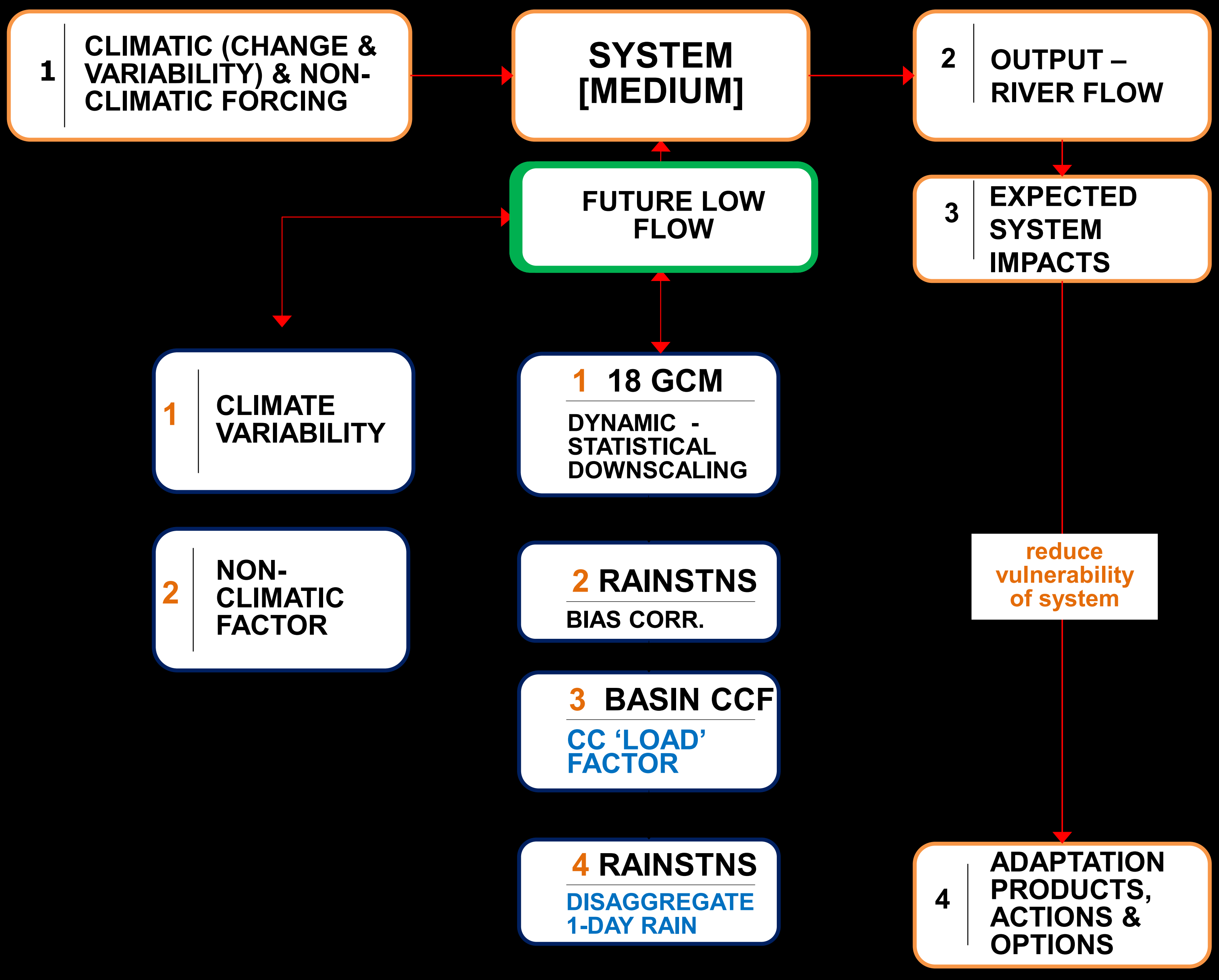
	2040-2050	2090-2100
Low Flow(m3/s)	2.91/(4.05)	6.16/(4.05)
High Flow(m3/s)	89.42/(98.42)	133.91/(98.42)

- May be some **potential water supply problems** in the future at Sabah, specifically at Kinabatangan, Padas and Kadamaian river basins,
- May be **significant flooding problems** throughout Sabah and Sarawak during the 21st century.

….develop climate change engineering knowledge, methodology & design standards…….

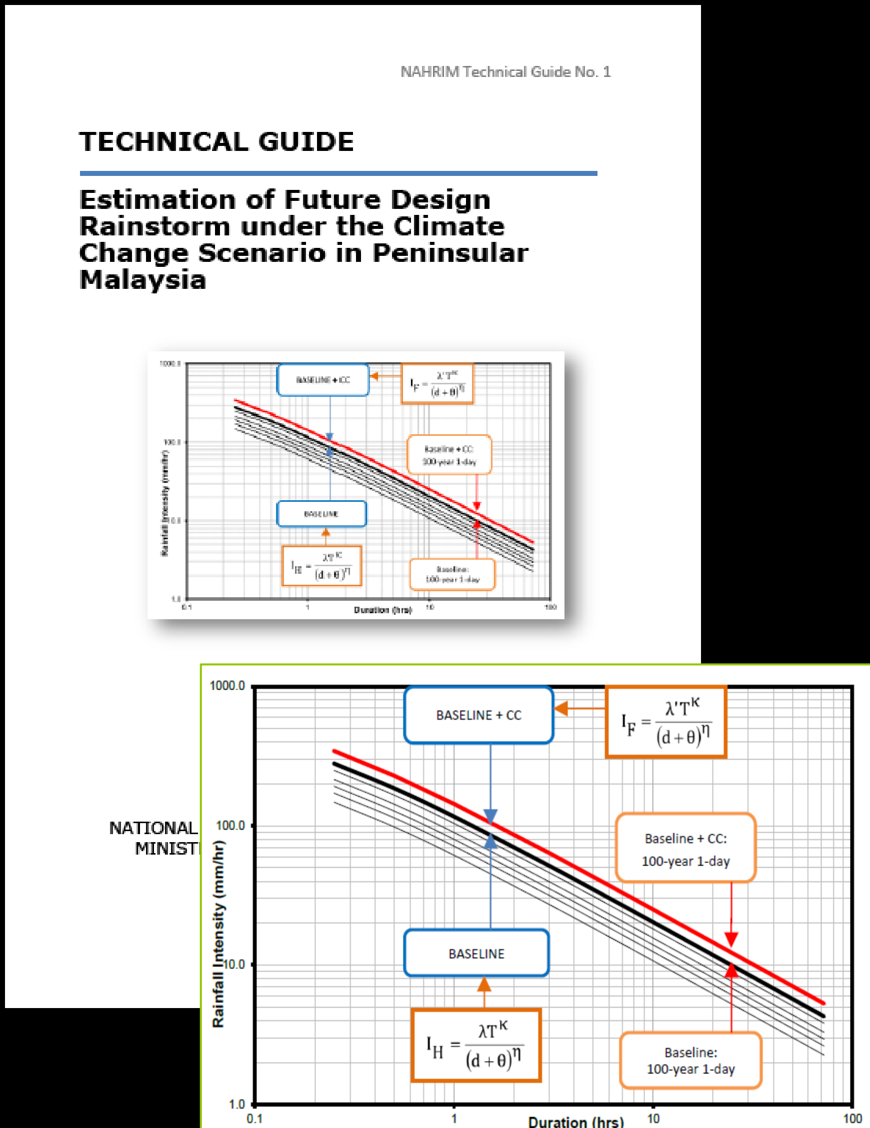
…..common questions in water resources engineering …….

- **How high should a bund be, and what is the risk to those living behind it?**
- **How to manage a reservoir to accommodate uncertain runoff**?
- **How safe is the structure under extreme flood conditions**?
- **What criteria should be used to "recertify" flood mitigation structures?**
- **What flood frequency distribution should be used in a particular analysis to accommodate climate uncertainty?**



1 CLIMATIC (CHANGE & VARIABILITY) & NON-CLIMATIC FORCING
SYSTEM [MEDIUM]
2 OUTPUT – RIVER FLOW
FUTURE LOW FLOW
3 EXPECTED SYSTEM IMPACTS
1 CLIMATE VARIABILITY
2 NON-CLIMATIC FACTOR
1 18 GCM
DYNAMIC - STATISTICAL DOWNSCALING
2 RAINSTNS
BIAS CORR.
3 BASIN CCF
CC 'LOAD' FACTOR
4 RAINSTNS
DISAGGREGATE 1-DAY RAIN
reduce vulnerability of system
4 ADAPTATION PRODUCTS, ACTIONS & OPTIONS
NAHRIM

Technical Guide No. 1: Estimation of Future Design Rainstorm under the Climate Change Scenario in Peninsular Malaysia (2013)

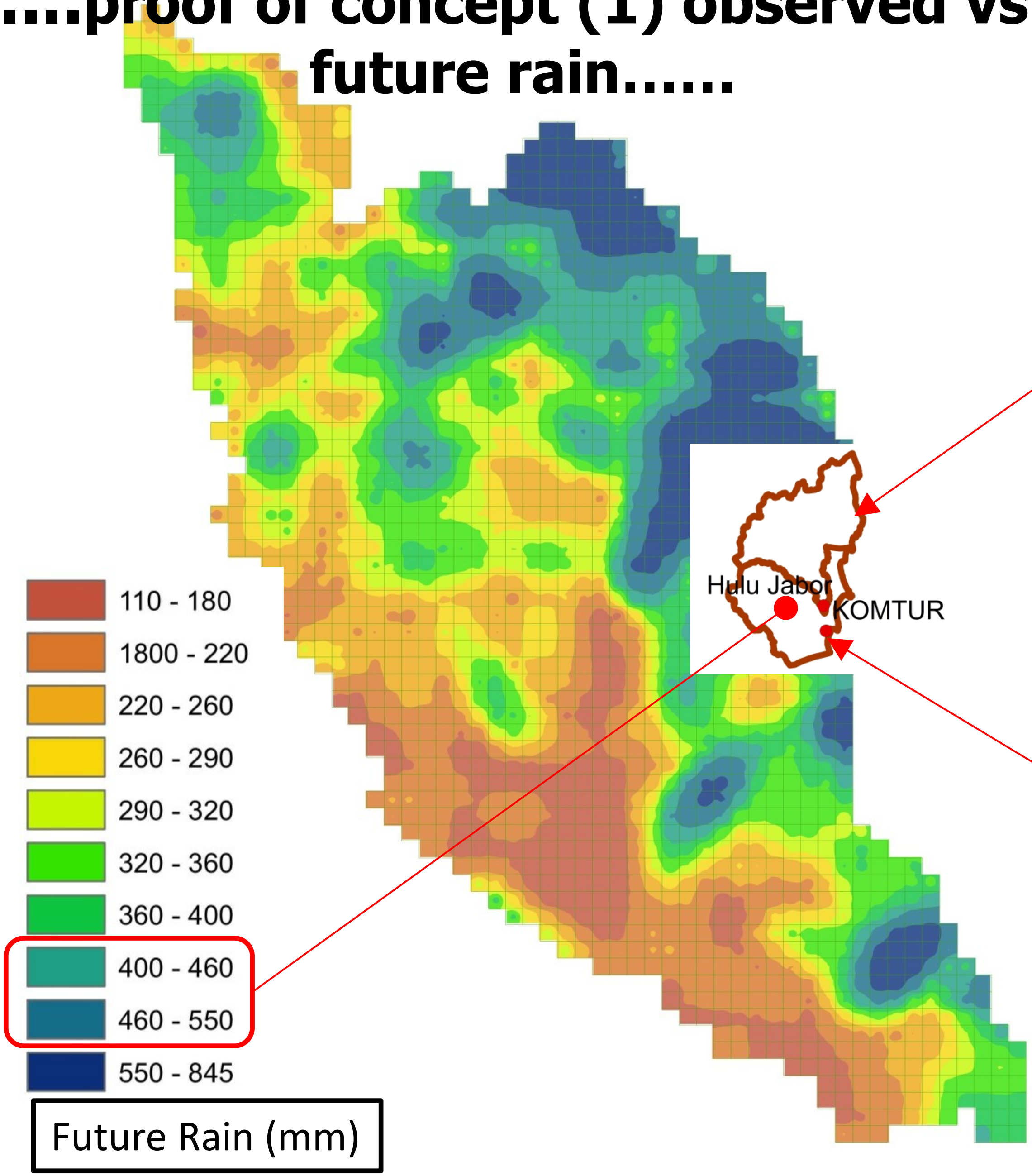


OBJECTIVES:

- To assist engineers, hydrologists and decision makers in designing, planning and developing water-related infrastructure under changing climatic conditions.
- To introduce an approach of quantifying the scale of climatic change to surface water systems.
- To derive climate change factor (CCF)

CCF – defined as the ratio of the design rainfall for each of the future periods (time horizons) to the control periods of historical rainfall)

....proof of concept (1) observed vs. future rain......



- KOMTUR = **541mm**
- Hulu Jabor = **500mm**

@ Sg Lembing PCC Mill

I_{100} =18.5mm/hr

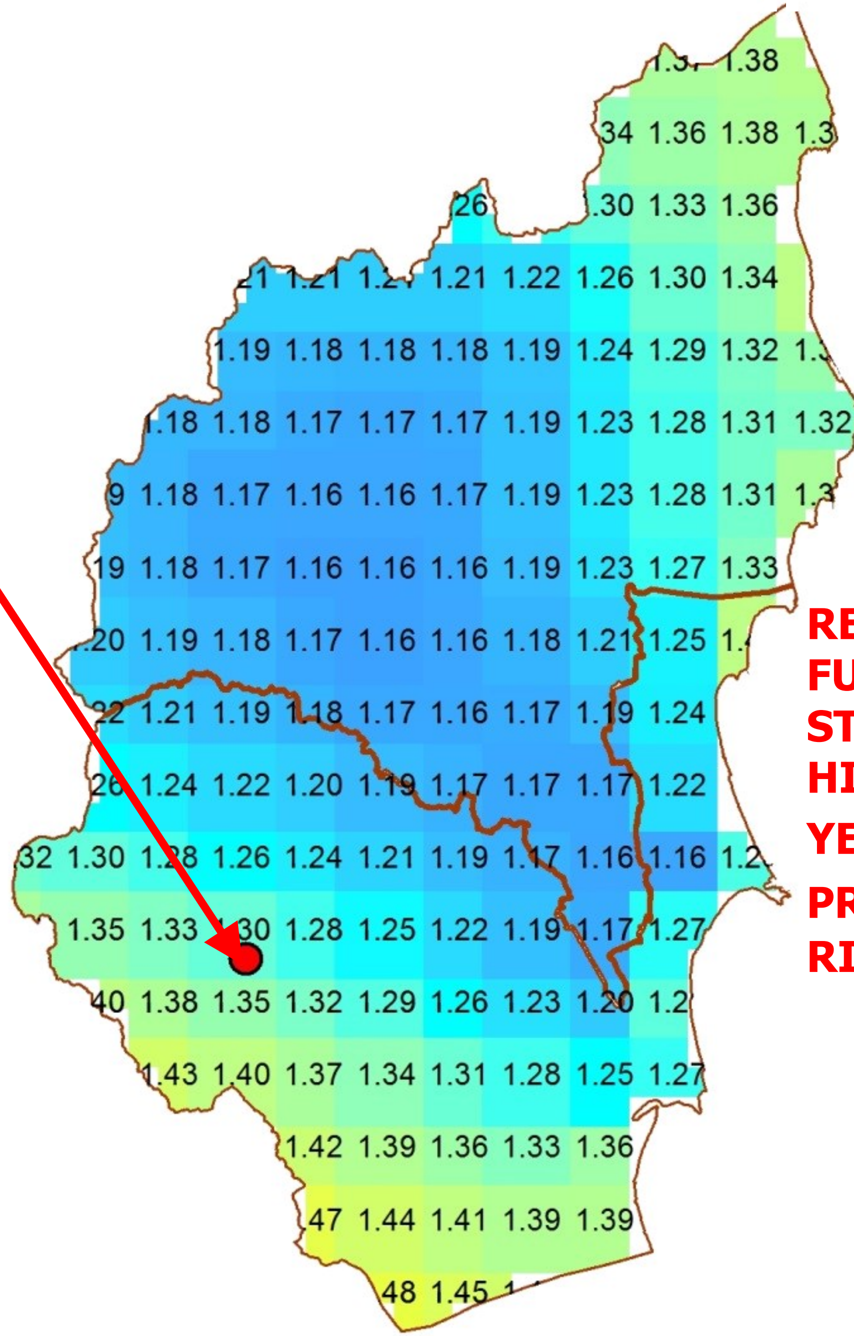
= **444mm**

I_{100} * 1.2 = **533**mm

* 1.3 = **578**mm

541mm

Day 3 (3rd Dec. 2013) @ KOMTUR

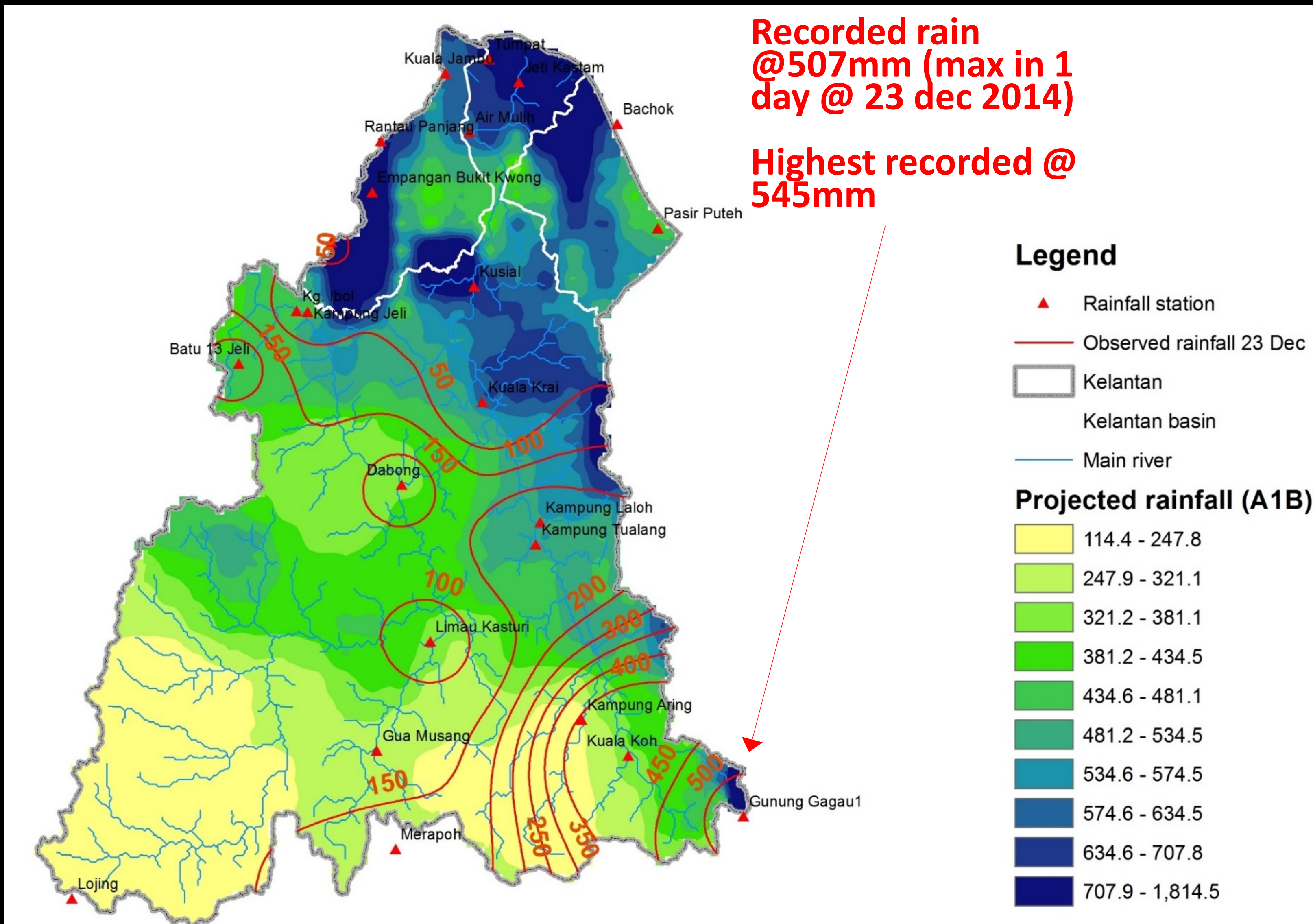


REMARK: FUTURE 100-YEAR STORM > HISTORICAL 100-YEAR STORM =↑ PROTECTION = ↓ RISK !

Projected rain @612mm

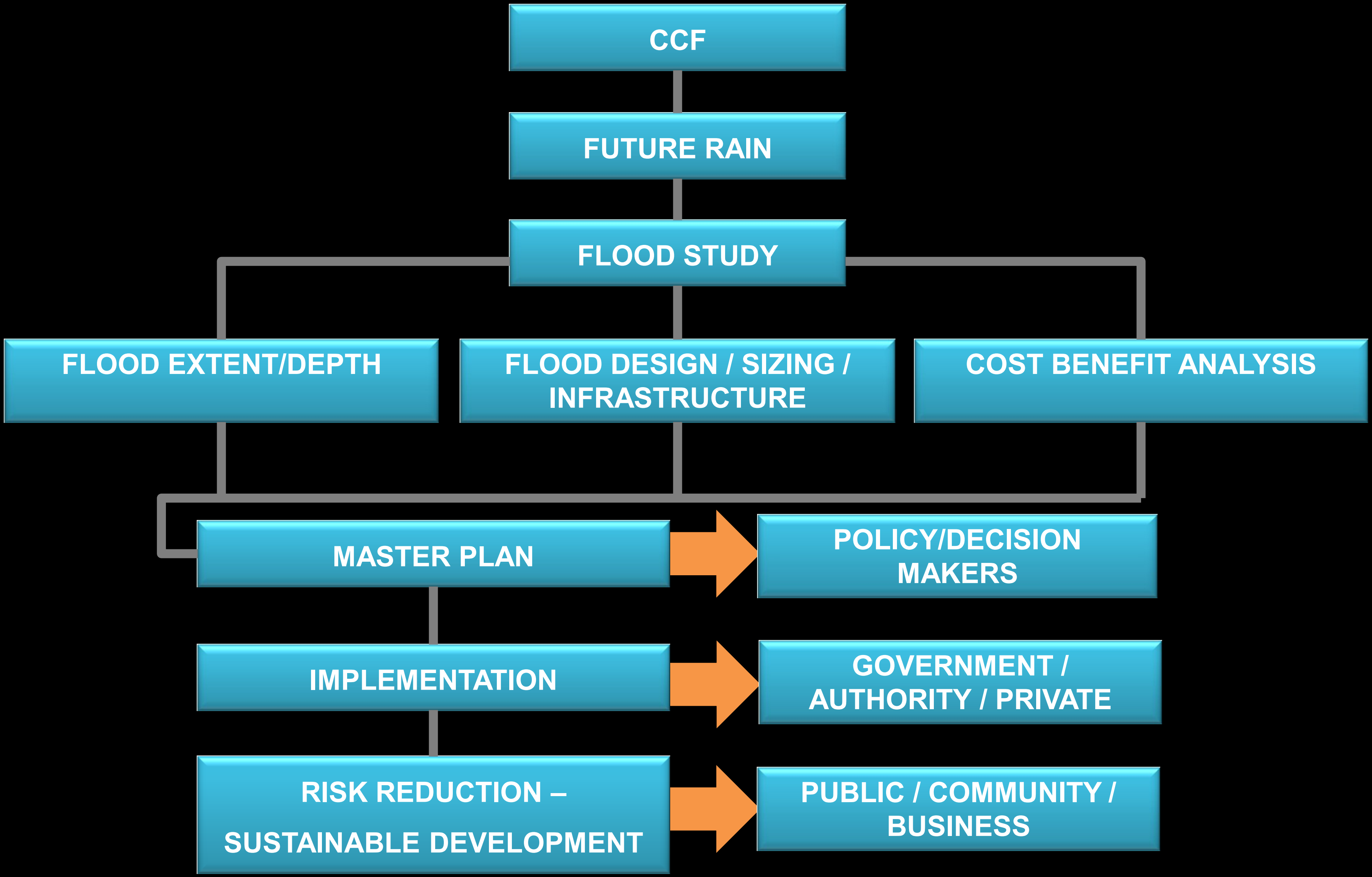
Recorded rain @507mm (max in 1 day @ 23 dec 2014)

Highest recorded @ 545mm



….apply engineering methodology for climate change adaptation…….

....how CCF works.....



.......projected magnitude of peak floods with climate forcing....

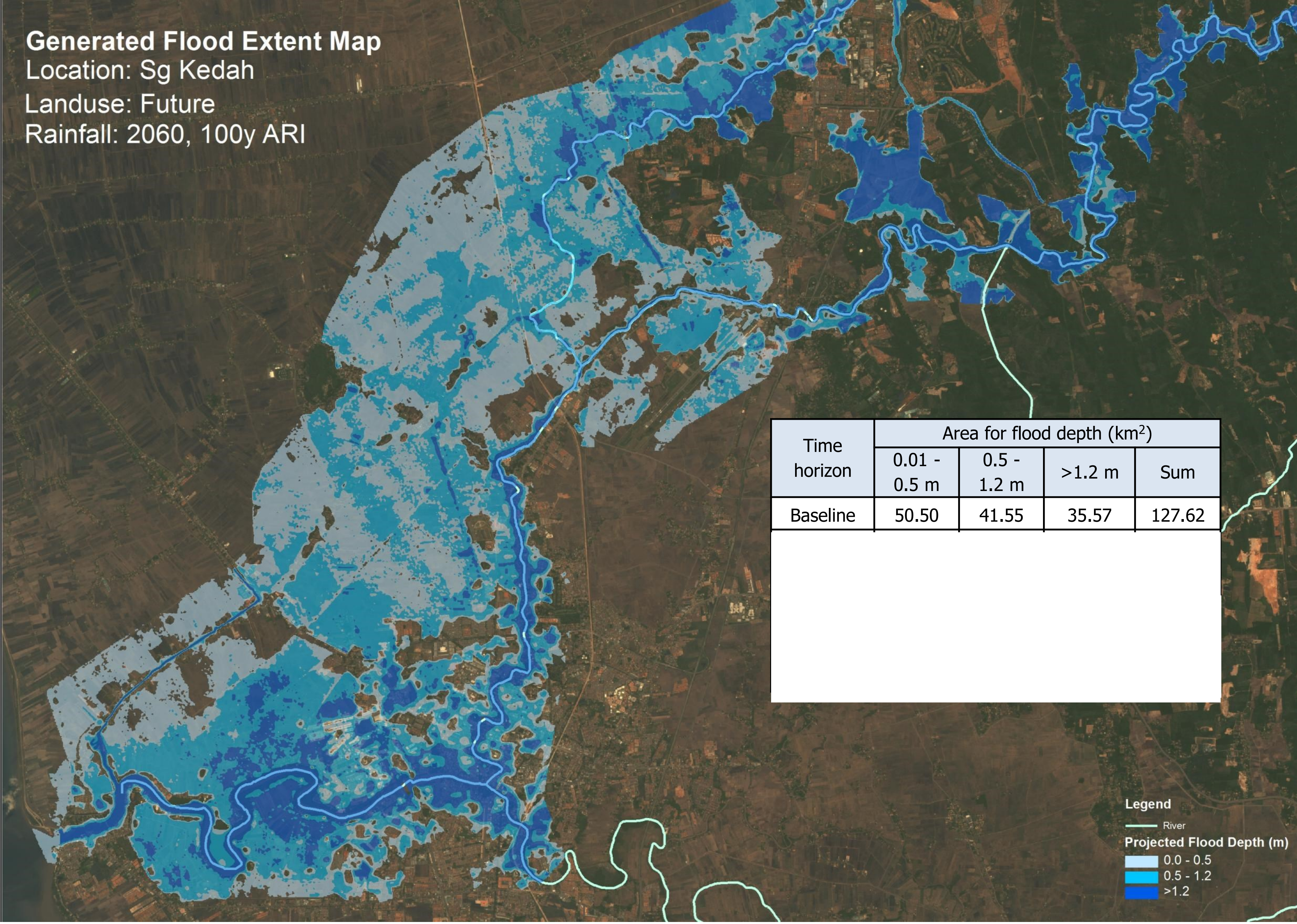
(a) Item	(b) Time Horizon	(c) Climate Change Factor (CCF)	Peak Discharges (Q) 100 years ARI		
			(d) 1-Day Design Rainfall (Baseline= 240.6 mm)	(e) **Baseline & Climate Change Scenario** Flood Magnitude, Qp (Baseline= 2047.9 m^3/s)	(f) Climate Change Scenario Floods Magnitude (m^3/s)
1	2020	1.05	245	**2111**	63.3[3.1]#
2	2030	1.09	257	**2268**	220.0[10.7]
3	2040	1.14	268	**2430**	382.3[18.7]
4	2050	1.19	280	**2602**	554.0[27.1]
5	2060	1.25	292	**2785**	737.4[36.0]

Note: [3.1]# denotes as percentage of change in flood magnitude due to increasing design rainfall.

…….projected magnitude of peak floods with climate & non-climate forcing….

(a) Item	(b) Time Horizon	(c) Climate Change Factor (CCF)	Peak Discharges (Q) 100 years ARI			
			(d) 1-Day Design Rainfall (Baseline= 241 mm)	(e) Baseline, CC & Future Landuse (Baseline Q_P= 2048 m^3/s)	(f) Baseline & Climate Change Q_P (m^3/s)	(g) Adaptation value (m^3/s)
1	2020	1.05	245	**2313**	**2111**	**266**
2	2030	1.09	257	**2477**	**2268**	**429**
3	2040	1.14	268	**2645**	**2430**	**598**
4	2050	1.19	280	**2824**	**2602**	**776**
5	2060	1.25	292	**3014**	**2785**	**966**

Note: [3.1]# denotes as percentage of change in flood magnitude due to increasing design rainfall.

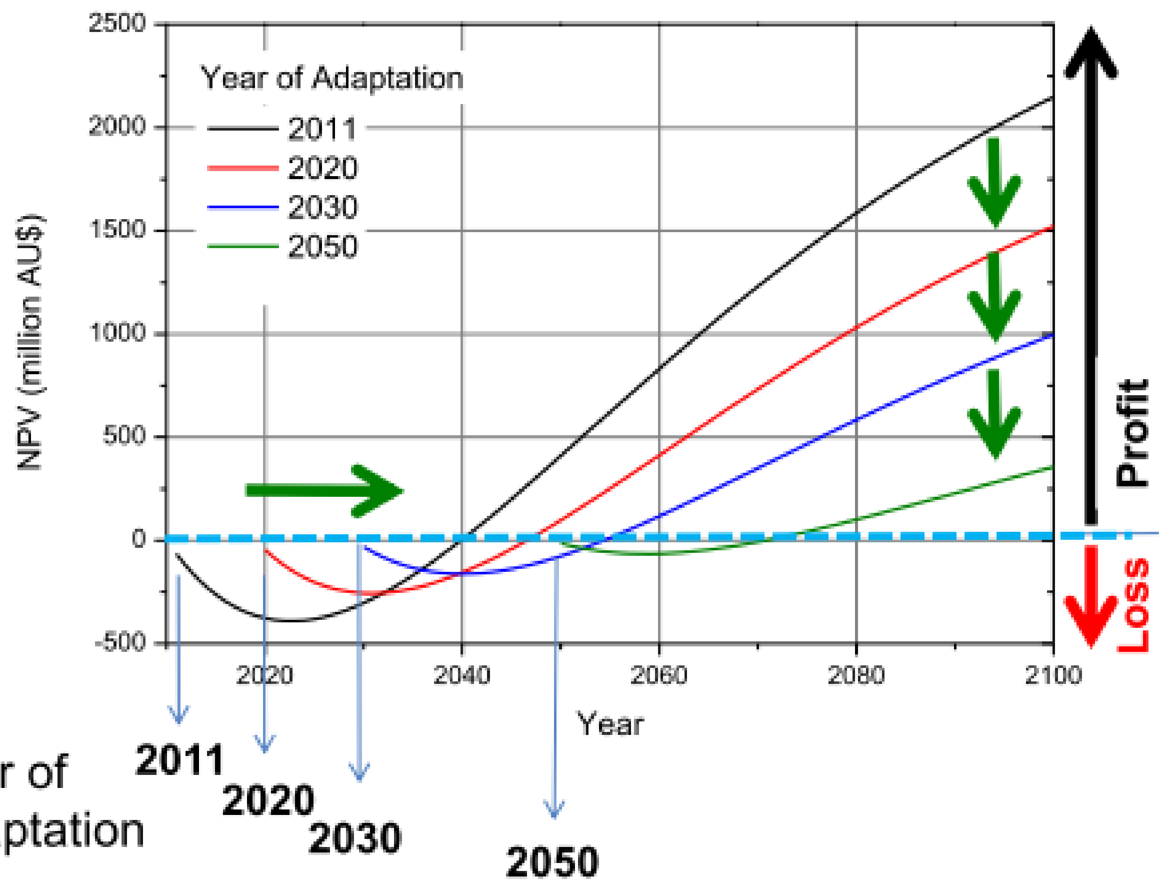


Time horizon	Area for flood depth (km^2)			
	0.01 - 0.5 m	0.5 - 1.2 m	>1.2 m	Sum
Baseline	50.50	41.55	35.57	127.62

….informing policy maker or planner….by means of economics assessment…..

..knowledge to informing policy making through cost benefit analysis….

NPV (Net Present Value) = Benefit - Cost



- To maintain long-term view in policy-making and planning
- Late action in adaptation may reduce the benefit significantly

Impact of Floods in Kedah Basin

Estimated Flood Damages	2010	2060
Total Flood Damages (RM mil)	503	7,047
Damages to Paddy	78	705
Damages to Residential & Commercial	244	2,886
GDP	**2010**	**2060**
State GDP (RM mil)	18,637	103,989
GDP for Agriculture Sector (RM mil)	1,556	5,221
GDP for Services Sector(RM mil)	8,151	67,994
ARI 100 Estimated Flood Impact	**2010**	**2060**
Total Flood Damages / State GDP (%)	**2.7%**	**6.8%**
Damages to Paddy / GDP for Agriculture Sector	**4.2%**	13.5%
Damages to Residential & Commercial / GDP for Services Sector	**2.4%**	4.2%
AAD Estimated Flood Impact	**2010**	**2060**
Total AAD Flood Damages / State GDP (%)	0.1%	0.1%
Annual Average Damage (RM mil)	27	74

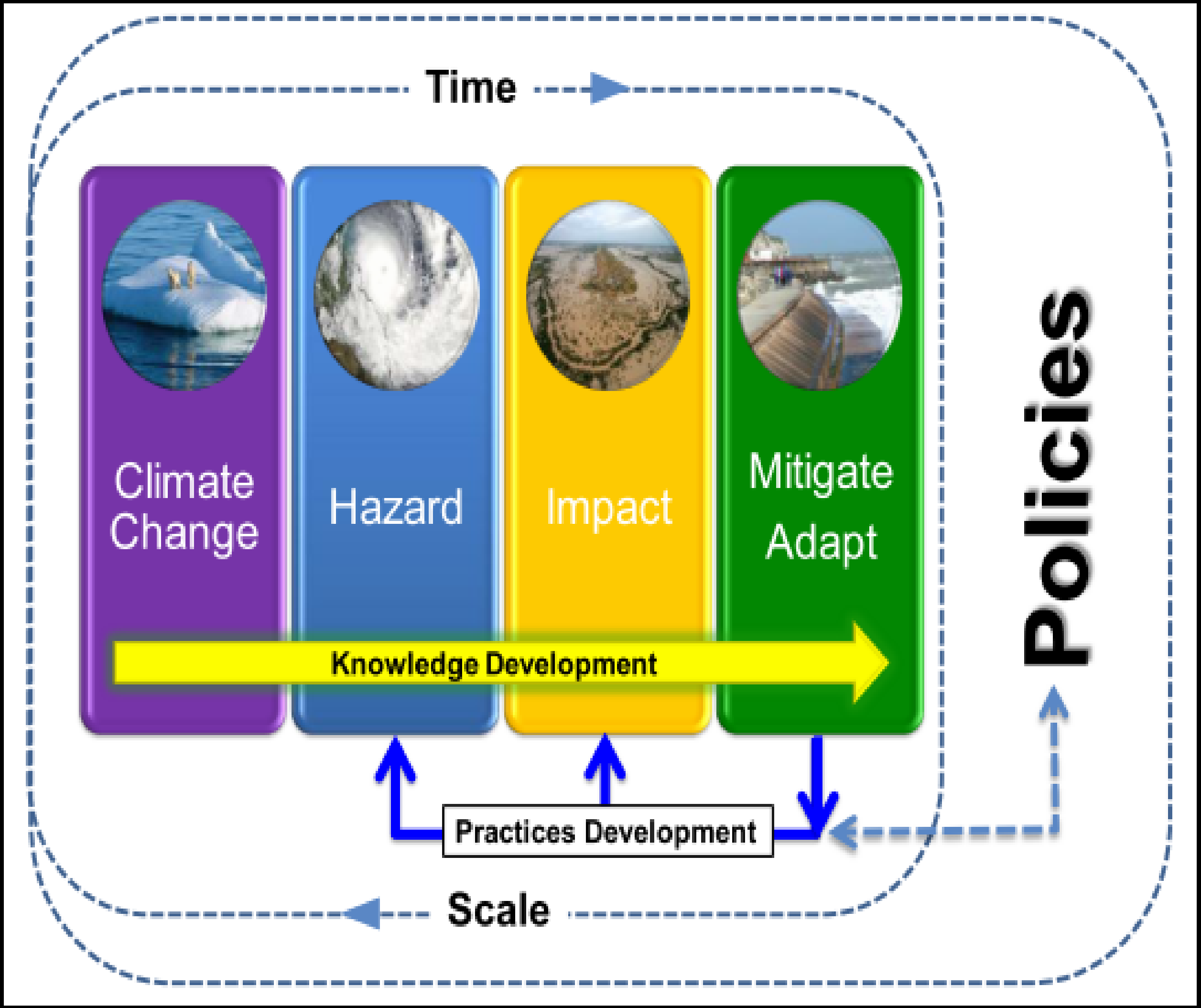
The impact of the 2010 floods on Kedah's economy

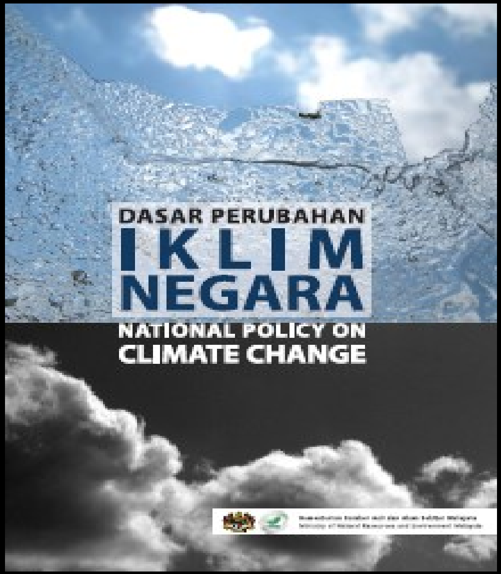
- Annual Average Damage (AAD) @ Baseline = **MYR 27 mil**
- Annual Average Damage (AAD) @ 2060 = **MYR 74 mil**
- Current cost of flood abatement program = **MYR 221 mil**
- Net Present Value for AAD until 2060 (benefit) = **MYR 800 – 1,400 mil**

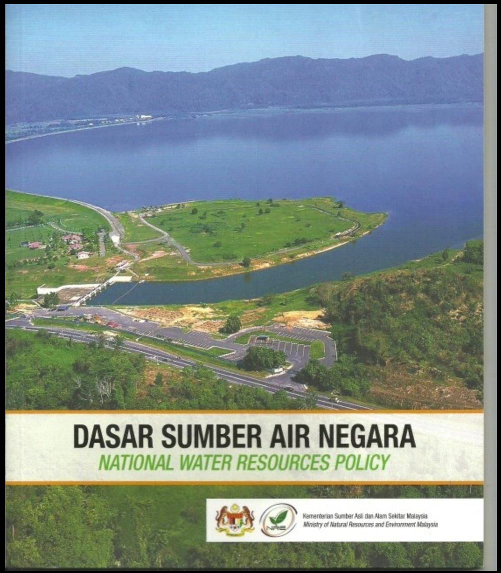
were maintained at current levels.

....subsequently, we have to "revisit" existing policy and provides pathway to adaptation measures and policy.....

.....pathways from knowledge to adaptation policies......

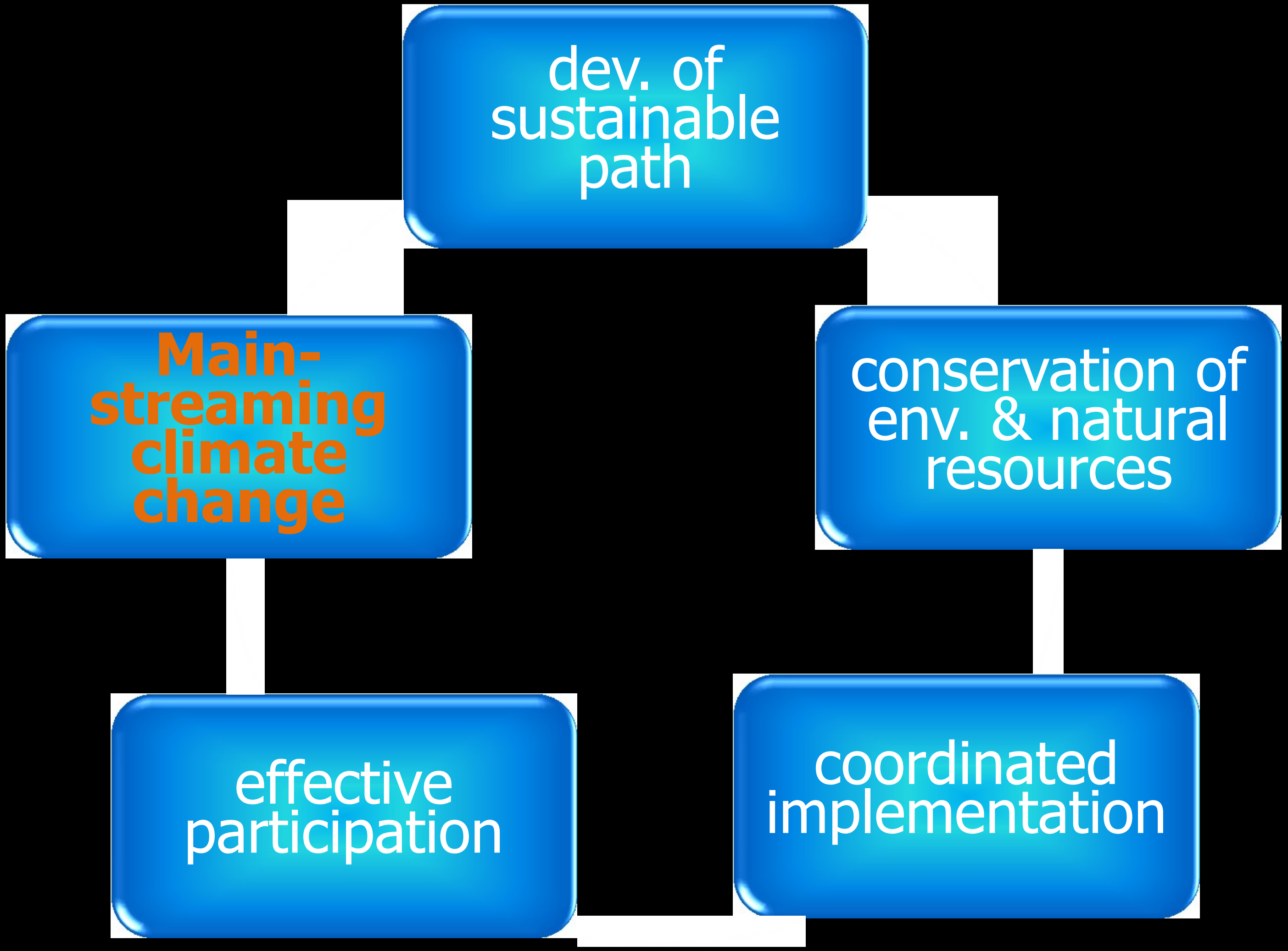




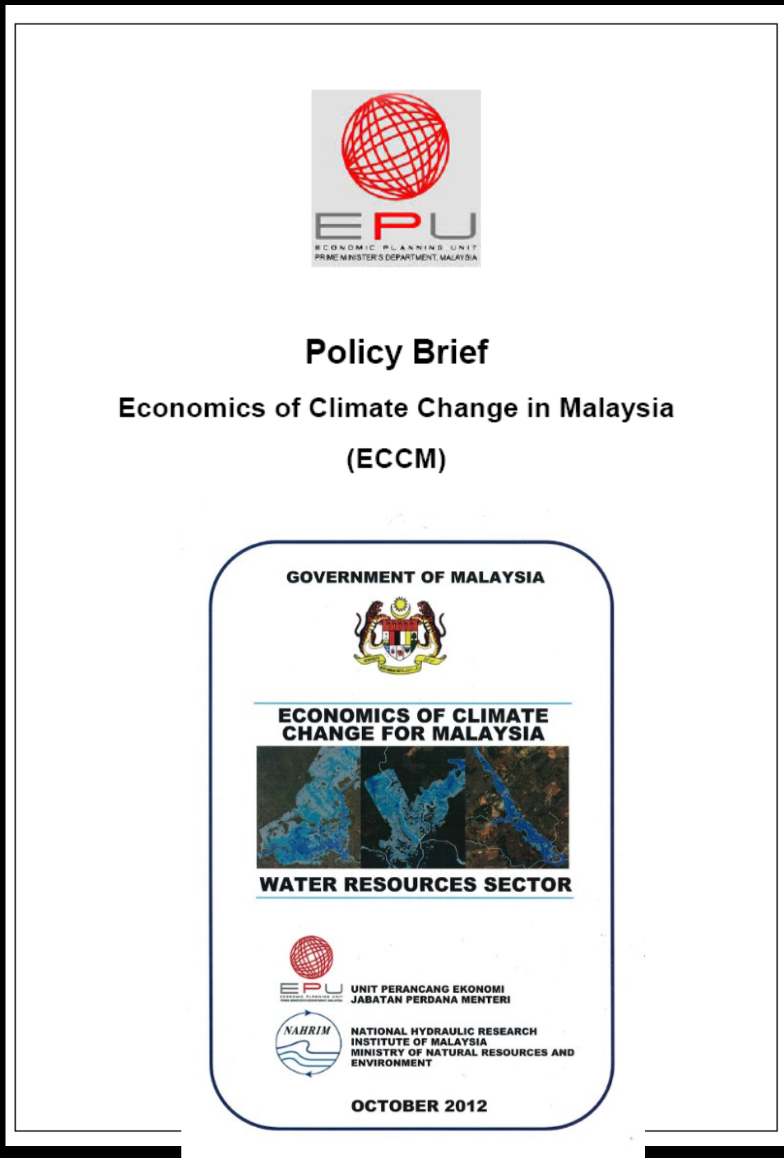


.....to strenghtening water related policies...

.....to strenghtening national policy on climate change.....5 main principles.....



Economic Planning Unit, Prime Minister's Department of Malaysia



ECONOMIC PLANNING UNIT
PRIME MINISTER'S DEPARTMENT, MALAYSIA

Policy Brief

Economics of Climate Change in Malaysia

(ECCM)

GOVERNMENT OF MALAYSIA

ECONOMICS OF CLIMATE CHANGE FOR MALAYSIA

WATER RESOURCES SECTOR

UNIT PERANCANG EKONOMI
JABATAN PERDANA MENTERI

NATIONAL HYDRAULIC RESEARCH INSTITUTE OF MALAYSIA
MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT

OCTOBER 2012

Department Of Irrigation & Drainage Malaysia

(39) P.P.S 11/12/3 (HP)

MALAYSIA

JABATAN PENGAIRAN DAN SALIRAN,
MALAYSIA

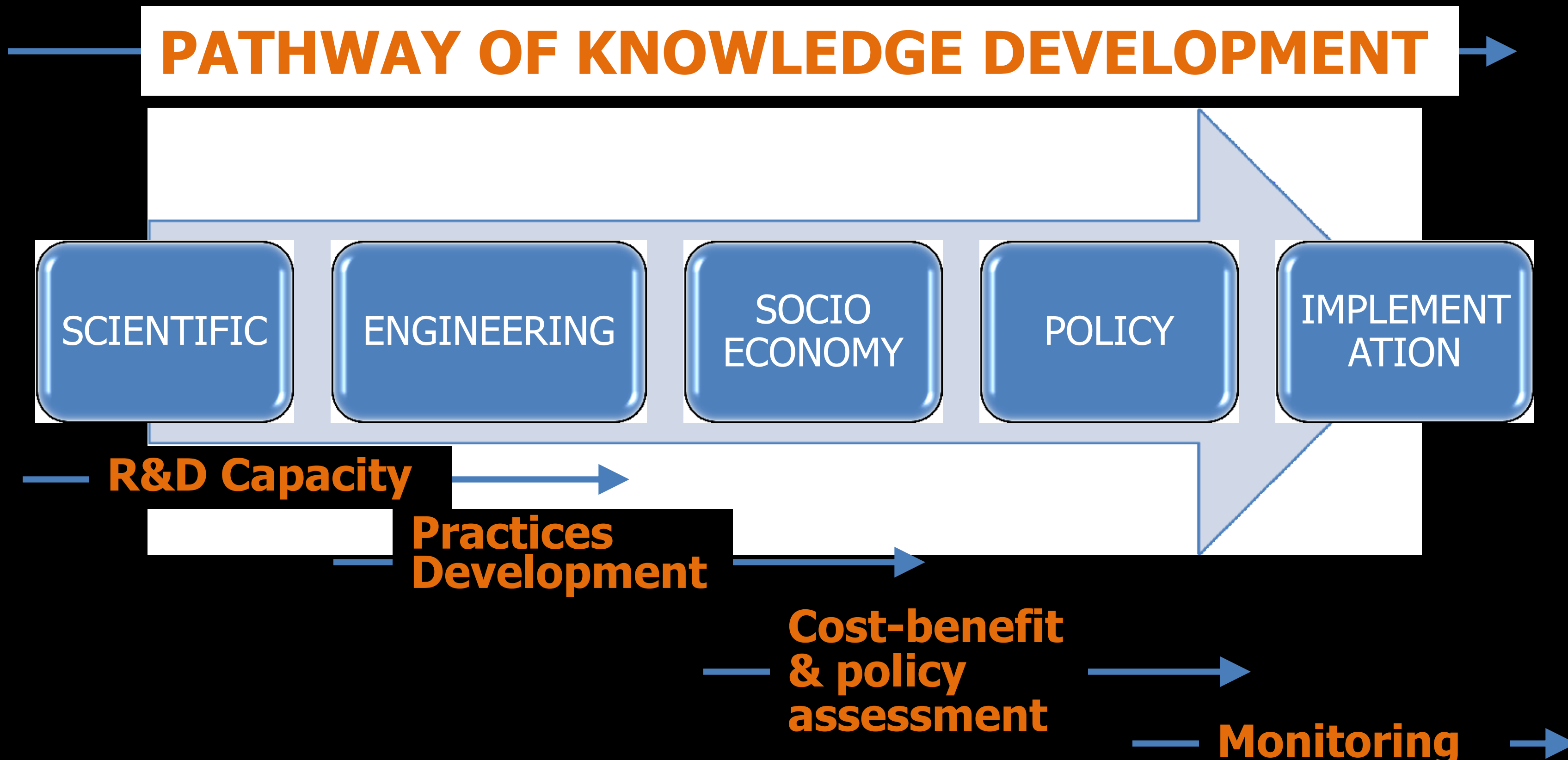
SURAT PEKELILING JPS BIL. 1 TAHUN 2014

COMPLIANCE WITH THE USE OF ' NAHRIM TECHNICAL GUIDE FOR ESTIMATION OF FUTURE DESIGN RAINSTORM UNDER THE CLIMATE CHANGE SCENARIO IN PENINSULAR MALAYSIA' FOR ALL DESIGN PROJECTS

- Risk assessment for floods
- Mainstream Climate Change in Land Use Planning
- Engage with all levels of Government and Society
- Share best practices in water management
- Invest in Climate Proofing Strategies

……Summary……

- MEETING THE CHALLENGE – early planning, best available information & modifying existing planning mechanism towards climate resilient
- KNOWLEDGE GAP - Pathway to bridge the gap between scientific knowledge into engineering knowledge and practices is developed



THANK YOU

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http:/www.nahrim.gov.my