BRIEFING ON CLIMATE CHANGE DOWNSCALING APPLICATION FOR FLOOD RISK MANAGEMENT

WATER MANAGEMENT | CLIMATE CHANGE

NATIONAL HYDRAULIC RESEARCH INSTITUTE OF MALAYSIA (NAHRIM)
MINISTRY OF WATER, LAND & NATURAL RESOURCES

OUTLINE

- INTRODUCTION
- FLOOD AND CLIMATE SCENARIO
- SETTING THE CONTEXT - CLIMATE PROJECTION
- WATER PLANNING – FLOOD RISK MANAGEMENT
- CONCLUSION – KEY MESSAGE
- **WEB PORTAL** - HYDRO-CLIMATE DATA ANALYSIS ACCELERATOR

NAHRIM IN GENERAL

VISION

- To be the premier hydraulic research centre for water and its environment in the world by 2030.

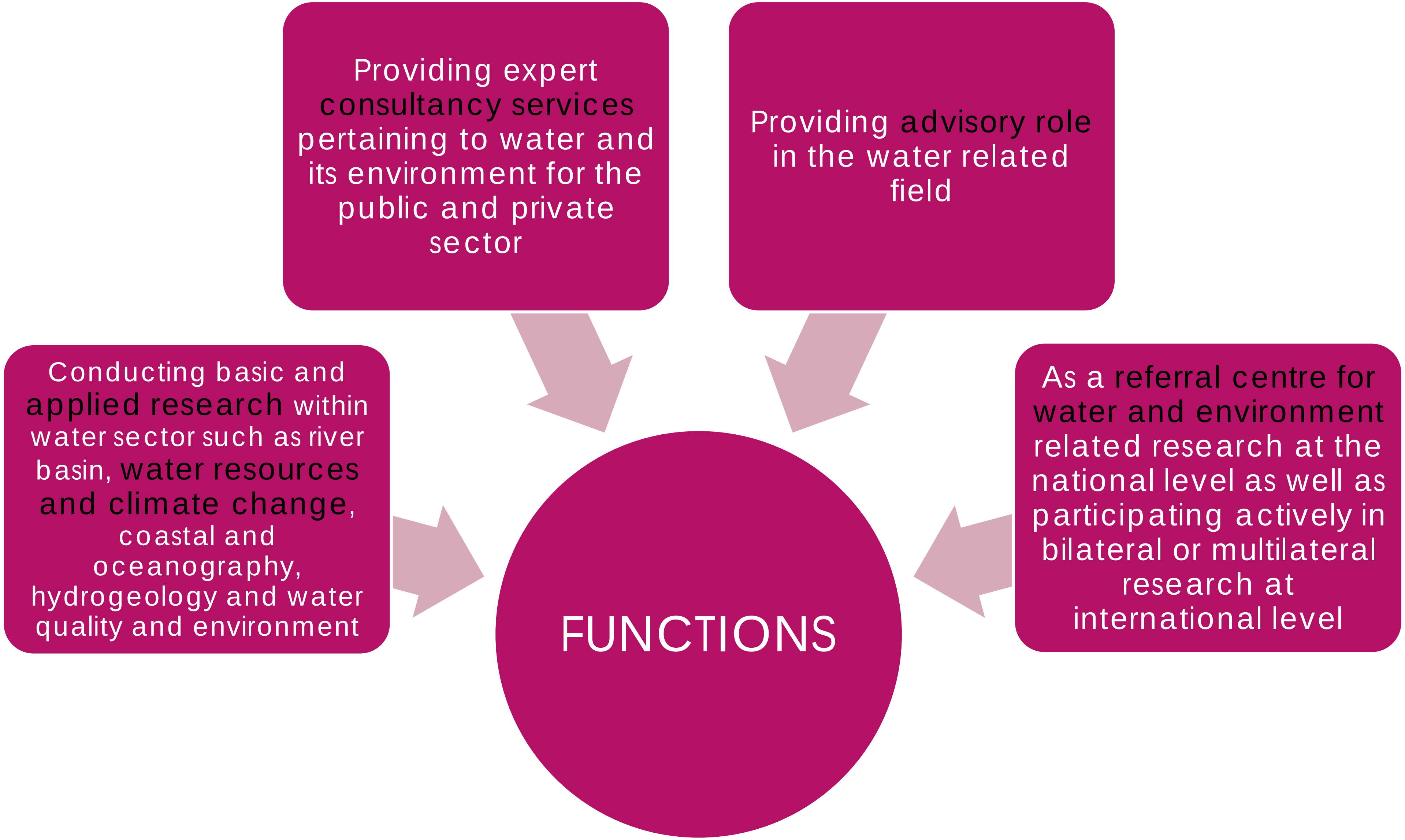
MISSION

- To provide excellent services as an expert centre on water and its environment management to ensure sustainable growth in order to improve the quality of life and well being

OBJECTIVES

- To be an excellent and main referral centre for water and it's environment.
- To be the national focal point to co-ordinate research activities in water and its environment
- To be the expert of consultancy service centre in development projects related to water and its environment.

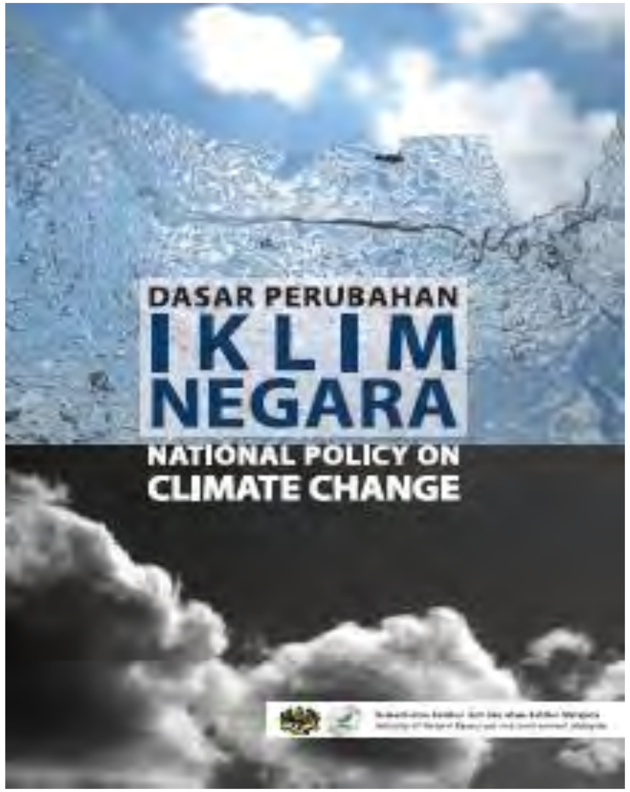
NAHRIM's FUNCTION



RESEARCH CENTRE & DIVISION

NATIONAL POLICY ON CLIMATE CHANGE, NPCC

- Established for ensuring climate-resilience development to fulfill national aspiration for sustainability
- Policy objective
  - mainstreaming climate change through wise management of resources and enhanced environmental conservation resulting in strengthened economic competitiveness and improved quality of life;
  - integration of responses into national policies, plans and programs to strengthen the resilience of development from arising and potential impacts of climate change;
  - strengthening of institutional and implementation capacity to better harness opportunities to reduce negative impacts of climate change. - Green technology shall be a driver to accelerate the national economy and promote sustainable development;



Ministry of Land, Water and Natural Resources (KATS) Malaysia. Formerly known as Ministry of Natural Resources & Environment (NRE)

11TH MALAYSIA PLAN (MP 11)

MP11

Climate Resilient Development

ISSUES AND CHALLENGE

Climate change and environment degradation

Governance in addressing issues of climate change and environment

2016-2020: WAY FORWARD

Strengthening enabling environment for climate change resilient

Strengthening resilient against climate change and natural disasters

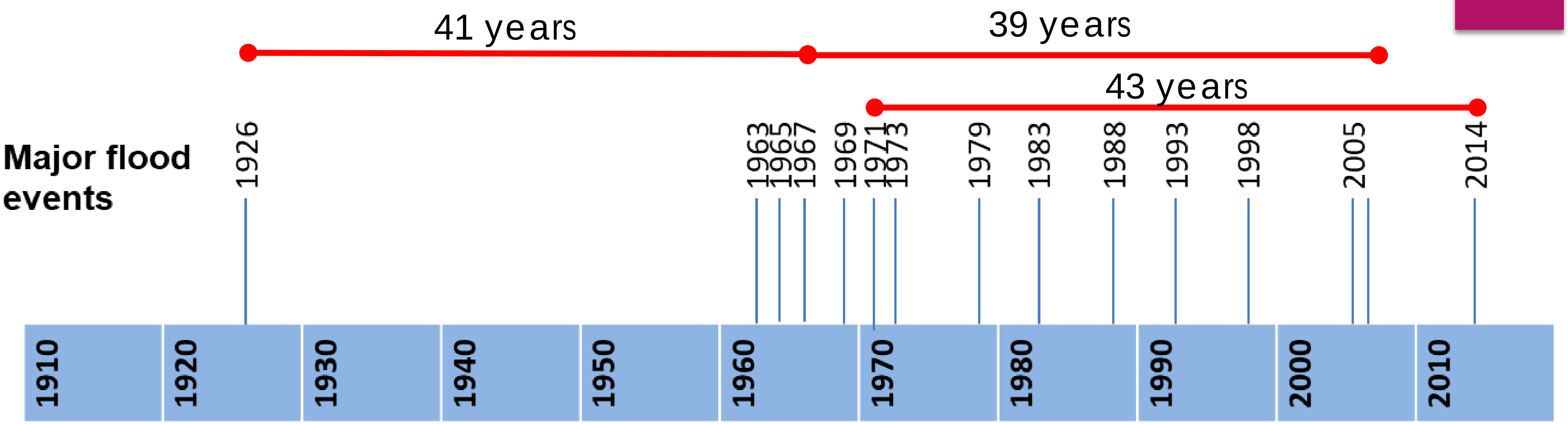
Harnessing economic value through sustainable consumption and production practices

SDG – KATS COMMITMENT

OUTLINE

- INTRODUCTION
- FLOOD AND CLIMATE SCENARIO
- SETTING THE CONTEXT - CLIMATE PROJECTION
- WATER PLANNING – FLOOD RISK MANAGEMENT
- CONCLUSION – KEY MESSAGE
- WEB PORTAL - HYDRO-CLIMATE DATA ANALYSIS ACCELERATOR

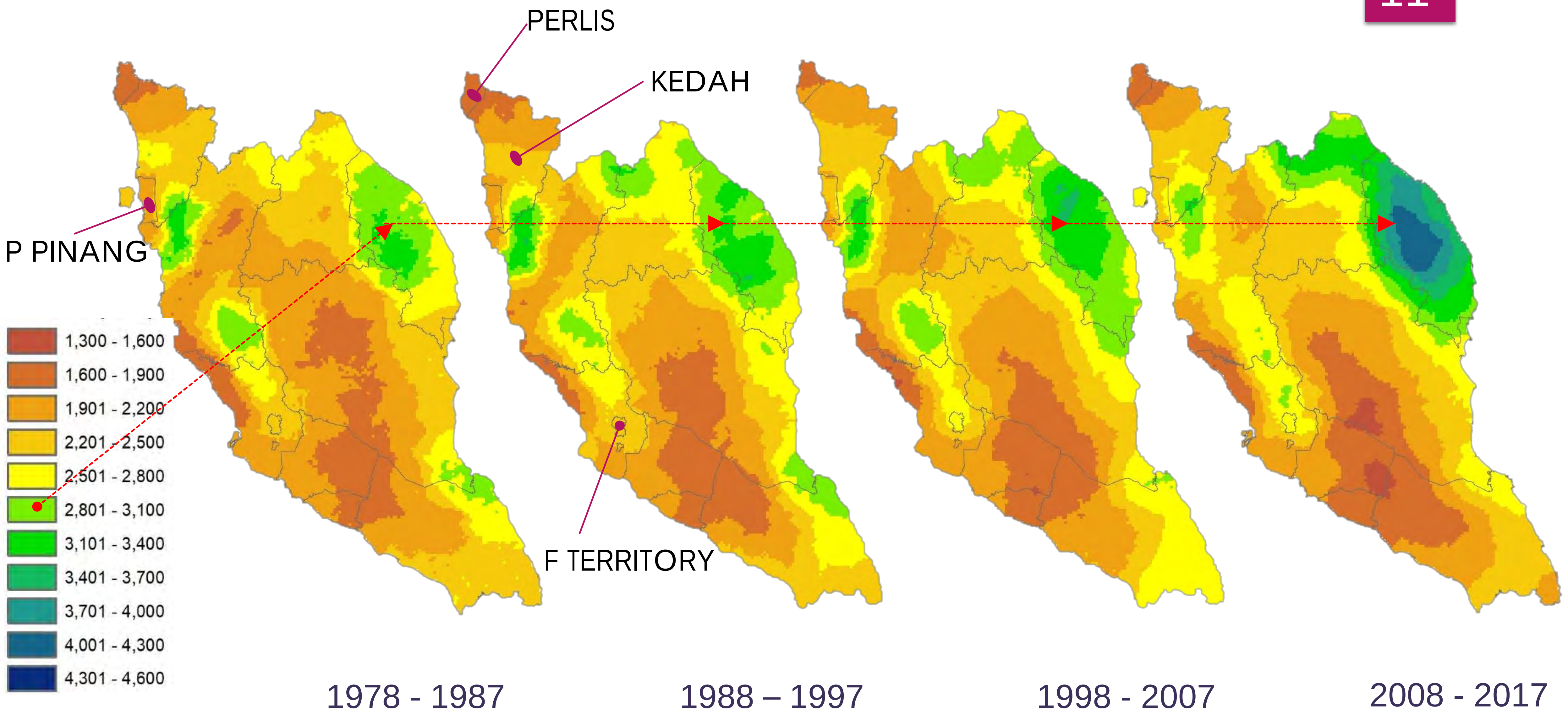
FLOOD IMPACT



2014

- Continuous heavy downpour & upstream flooding..
- many properties & infrastructures destroyed..

10 Years


PERLIS
KEDAH
P PINANG
F TERRITORY
1,300 - 1,600
1,600 - 1,900
1,901 - 2,200
2,201 - 2,500
2,501 - 2,800
2,801 - 3,100
3,101 - 3,400
3,401 - 3,700
3,701 - 4,000
4,001 - 4,300
4,301 - 4,600
1978 - 1987
1988 – 1997
1998 - 2007
2008 - 2017

MEAN YEARLY RAINFALL (MM) AND THE VARIATIONS FOR PENINSULAR MALAYSIA AND SABAH & SARAWAK

PENINSULAR MALAYSIA	40 years	20 YEARS		10 YEARS			
		1978-1997 (First 20-yr analysis period)	1998-2017 (Second 20-yr analysis period)	1978-1987 (First 10-yr analysis period)	1988-1997 (Second 10-yr analysis period)	1998-2007 (Third 10-yr analysis period)	2008-2017 (Fourth 10-yr analysis period)
Mean Yearly Rainfall (mm)	2,360	2,339	2,413	2,283	2,357	2,366	2,447
Increase/Decrease		-	+74 mm	-	+74 mm	+83 mm	+164 mm
Percentage		-	(+3.2%)	-	(+3.2%)	(+3.64%)	(+7.2%)
SABAH & SARAWAK	40 years	20 YEARS		10 YEARS			
		1978-1997 (First 20-yr analysis period)	1998-2017 (Second 20-yr analysis period)	1978-1987 (First 10-yr analysis period)	1988-1997 (Second 10-yr analysis period)	1998-2007 (Third 10-yr analysis period)	2008-2017 (Fourth 10-yr analysis period)
Mean Yearly Rainfall (mm)	3,163	2,959	3,284	2,757	3,016	3,282	3,256
Increase/Decrease		-	+325 mm	-	+259 mm	+525 mm	+499 mm
Percentage		-	(+11.0%)	-	(+9.4%)	(+19.1%)	(+18.1%)

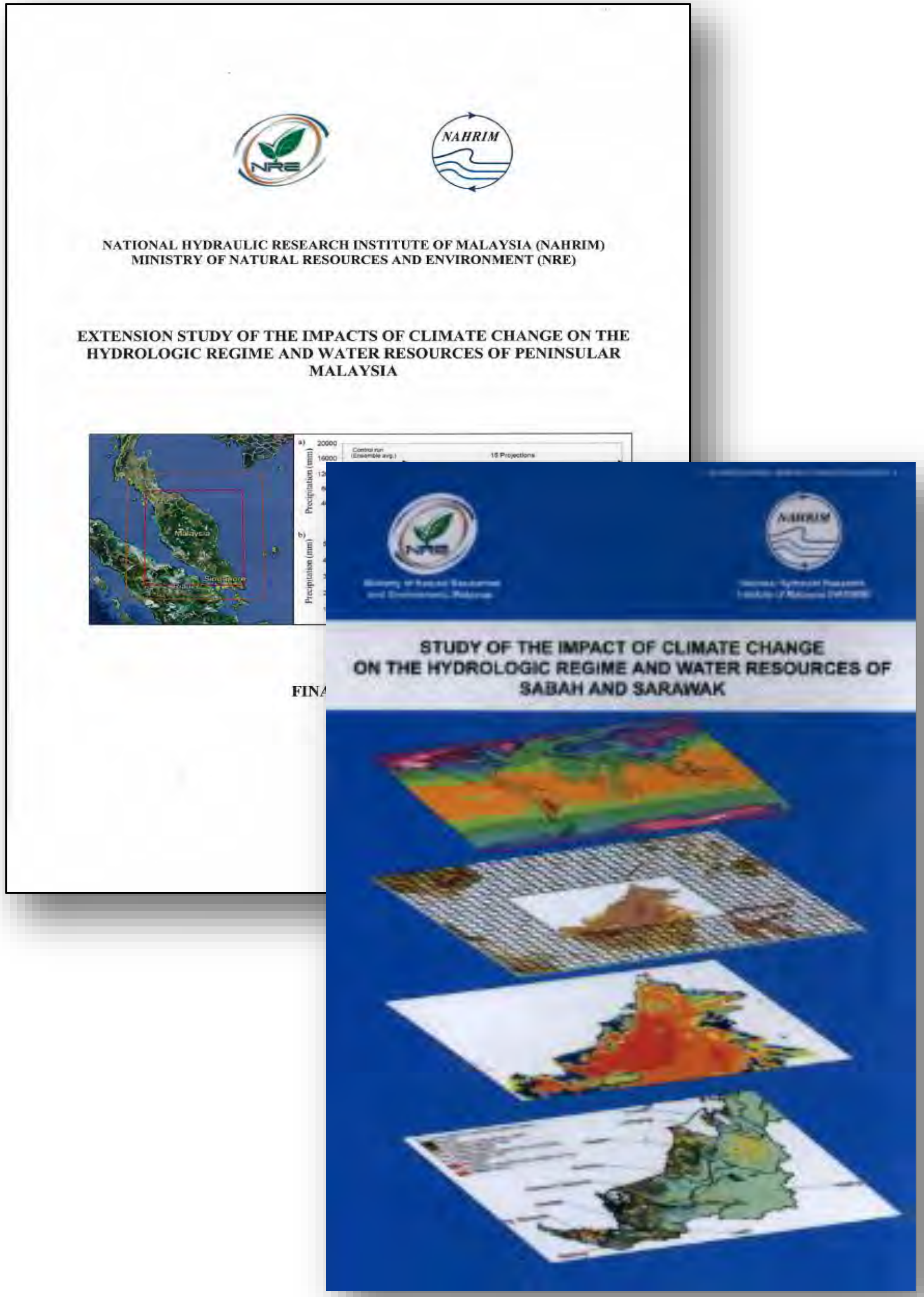
MEAN MAXIMUM RAINFALL (MM) OF VARIOUS RAINFALL DURATIONS AND THEIR VARIATIONS FOR PENINSULAR MALAYSIA

State	Analysis Periods	Period	15-min	30-min	1-hr	3-hr	6-hr	12-hr	1-day	2-day	3-day	5-day	7-day	14-day
Peninsular Malaysia	40-yr	1978-2017	33	50	67	88	103	120	135	175	203	247	282	381
	20-yr	First Period	30	42	58	80	93	110	126	166	195	238	273	371
		Second Period	34	51	69	91	105	122	143	182	211	254	290	390
		Increase/Decrease	4	9	11	11	12	12	17	16	16	16	17	19
		Percentage (%)	+13.3	+21.4	+19.0	+13.8	+12.9	+10.9	+13.5	+9.6	+8.2	+6.7	+6.2	+5.1
	10-yr	First Period	32	44	59	81	93	109	124	165	195	240	275	374
		Second Period	30	42	57	80	94	112	127	167	194	235	270	367
		Increase/Decrease	-2	-2	-2	-1	1	3	3	2	-1	-5	-5	-7
		Percentage (%)	-6.3	-4.5	-3.4	-1.2	+1.1	+2.8	+2.4	+1.2	-0.5	-2.1	-1.8	-1.9
		Third Period	34	50	68	92	107	124	139	177	205	249	283	381
		Increase/Decrease	2	6	9	11	14	15	15	12	10	9	8	7
		Percentage (%)	+6.3	+13.6	+15.3	+13.6	+15.1	+13.8	+12.1	+7.3	+5.1	+3.8	+2.9	+1.9
		Fourth Period	34	52	69	90	104	122	147	187	217	260	298	400
		Increase/Decrease	2	8	10	9	11	13	23	22	22	20	23	26
		Percentage (%)	+6.3	+18.2	+16.9	+11.1	+11.8	+11.9	+18.5	+13.3	+11.3	+8.3	+8.4	+7.0

OUTLINE

- INTRODUCTION
- FLOOD AND CLIMATE SCENARIO
- SETTING THE CONTEXT - CLIMATE PROJECTION
- WATER PLANNING – FLOOD RISK MANAGEMENT
- CONCLUSION – KEY MESSAGE
- WEB PORTAL - HYDRO-CLIMATE DATA ANALYSIS ACCELERATOR

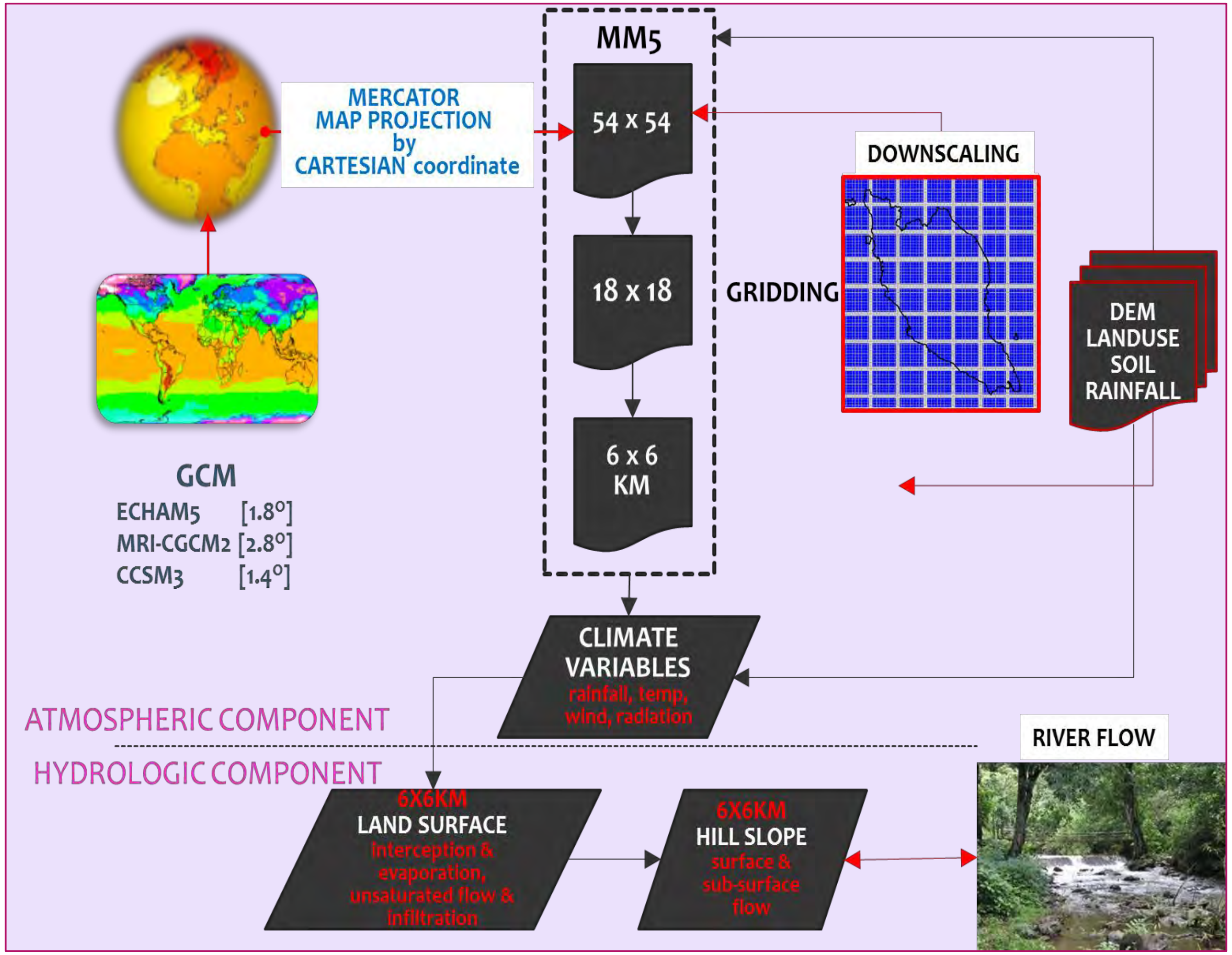
CLIMATE CHANGE STUDY



- Study of The Impact of Climate Change on The Hydrologic Regime and Water Resources of Peninsular Malaysia (2006)
- Climate Projection Downscaling for Malaysia Using Hadley Centre PRECIS Model (2010)
- Study of the Impact of Climate Change on Sea Level Rise (SLR) in Malaysia (2010);
- Study of the Impact of Climate Change on Hydrologic Regime and Water Resources of Sabah and Sarawak (2010)
- Extension Study of the Impact of Climate Change on the Hydrologic Regime and Water Resources of Peninsular Malaysia (2014) – IPCC AR4
- Extension Study of the Impact of Climate Change on the Hydrologic Regime and Water Resources of Malaysia (Phase 2) – Climate Model Inter-comparison Project Phase 5 (CMIP5) 2017-2019

REGIONAL HYDRO CLIMATE MODEL PENINSULAR MALAYSIA & SS (REGHCM-PM-SS)

- Dynamical downscaling - global-scale atmospheric data at coarse spatial and temporal resolutions are transformed to regional scale of Peninsular Malaysia & SS
- Mesoscale atmospheric model component and a regional land hydrology model component that was utilized



CLIMATE CHANGE SCENARIO

- 2014 CC STUDY

  A total of 1440 years of GCM data were downscaled to the study region: 15 future projections, each 90 years long that were simulated by the coupled atmosphere-ocean global climate models ECHAM5, CCSM3 and MRI, and three 30 years long simulations during the historical period by the three GCMs

Model Name	Run ID	GCM Grid Resolution	Period	Model Name	Run ID	GCM Grid Resolution	Period
ECHAM5 /MPIOM	20C	1.8 degree	1970-2000	MRI-CGCM2.3.2	20C	2.8 degree	1970-2000
	SRES A1B_1	1.8 degree	2010-2100				
	SRES A1B_2	1.8 degree	2010-2100		SRES A1B	2.8 degree	2010-2100
	SRES A1B_3	1.8 degree	2010-2100		SRES B1		2010-2100
	SRES A2_1	1.8 degree	2010-2100	CCSM3	20C	1.4 degree	1970-2000
	SRES A2_2	1.8 degree	2010-2100				
	SRES A2_3	1.8 degree	2010-2100		SRES A1B	1.4 degree	2010-2100
	SRES B1_1	1.8 degree	2010-2100		SRES A1FI		2010-2100
	SRES B1_2	1.8 degree	2010-2100		SRES A2	1.4 degree	2010-2100
	SRES B1_3	1.8 degree	2010-2100		SRES B1		2010-2100

List of future projections for four Representative Concentration Pathways greenhouse gas emission scenarios

GCM	Scenario	Realization	Period
CCSM4	RCP4.5	r6i1p1	2006-2100
	RCP8.5	r6i1p1	2006-2100
MIROC5	RCP2.6	r1i1p1	2006-2100
	RCP4.5	r1i1p1	2006-2100
	RCP6.0	r1i1p1	2006-2100
	RCP8.5	r1i1p1	2006-2100
MRI-CGCM3	RCP4.5	r1i1p1	2006-2100
	RCP8.5	r1i1p1	2006-2100
GFDL-ESM2M	RCP2.6	r1i1p1	2006-2100
	RCP4.5	r1i1p1	2006-2100
	RCP6.0	r1i1p1	2006-2100
	RCP8.5	r1i1p1	2006-2100
IPSL-CM5A-MR	RCP2.6	r1i1p1	2006-2100
	RCP4.5	r1i1p1	2006-2100
	RCP6.0	r1i1p1	2006-2100
	RCP8.5	r1i1p1	2006-2100

16 future climate projections by 5 GCMs - CCSM4, MIROC5, MRI-CGCM3, GFDL-ESM2M, and IPSL-CM5A-MR) and 4 RCPs at 6 km spatial resolution for the duration of 2006-2100 over Peninsular Malaysia and Sabah-Sarawak

Peninsular Malaysia : 13 river basins
Sabah – Sarawak : 25 river basins

6km x 6km spatial resolution grid

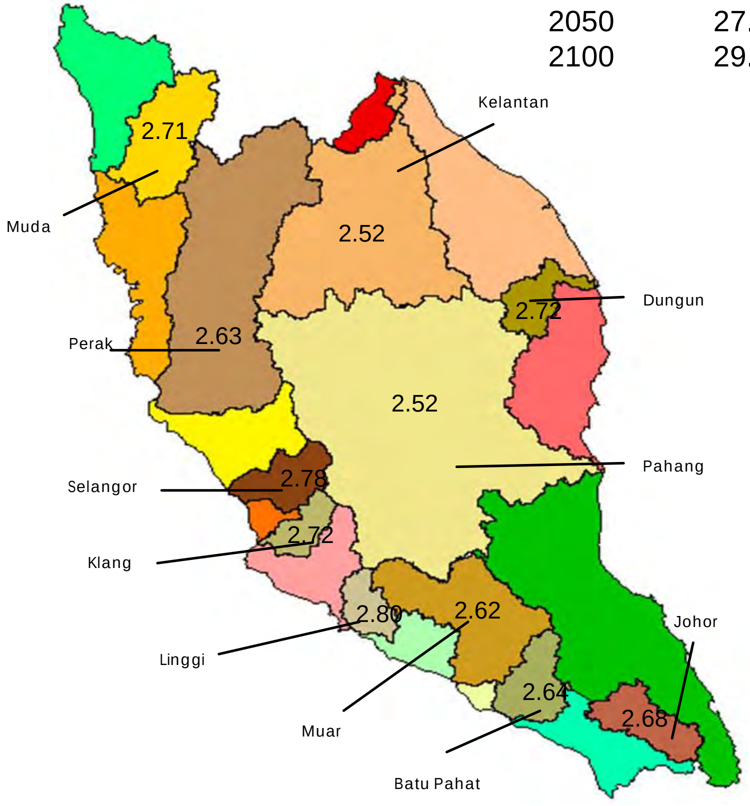
30-year Mean of Basin Average Surface Temperature by 2100

PENINSULAR MALAYSIA

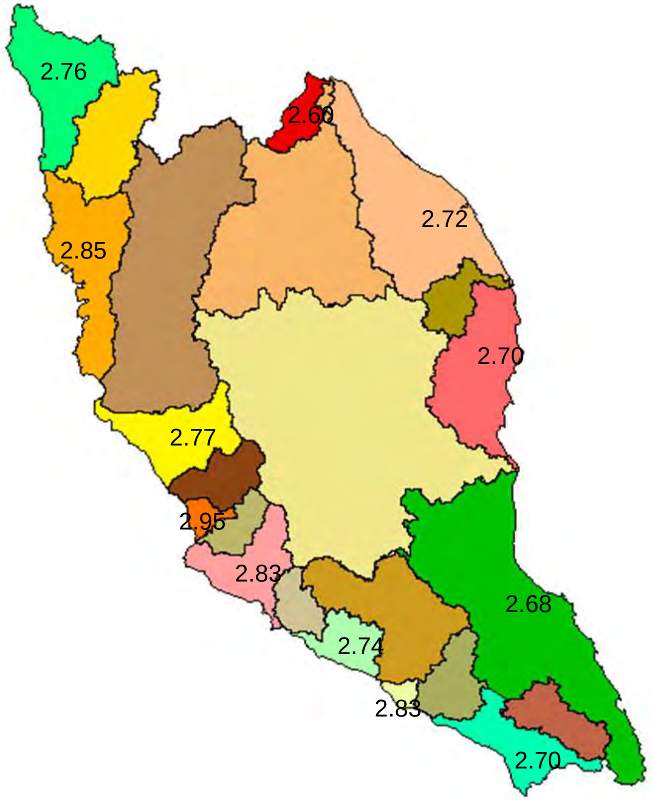
<u>Average Temperature</u>

Historical	26.29°C	
2050	27.26°C	(+0.96°C)
2100	29.97°C	(+2.72°C)

11 WATERSHEDS



12 COASTAL REGIONS



The annual mean air temperature increases more in the west coast area, and less in the mountainous area of Peninsular Malaysia.

Source: NAHRIM, 2014

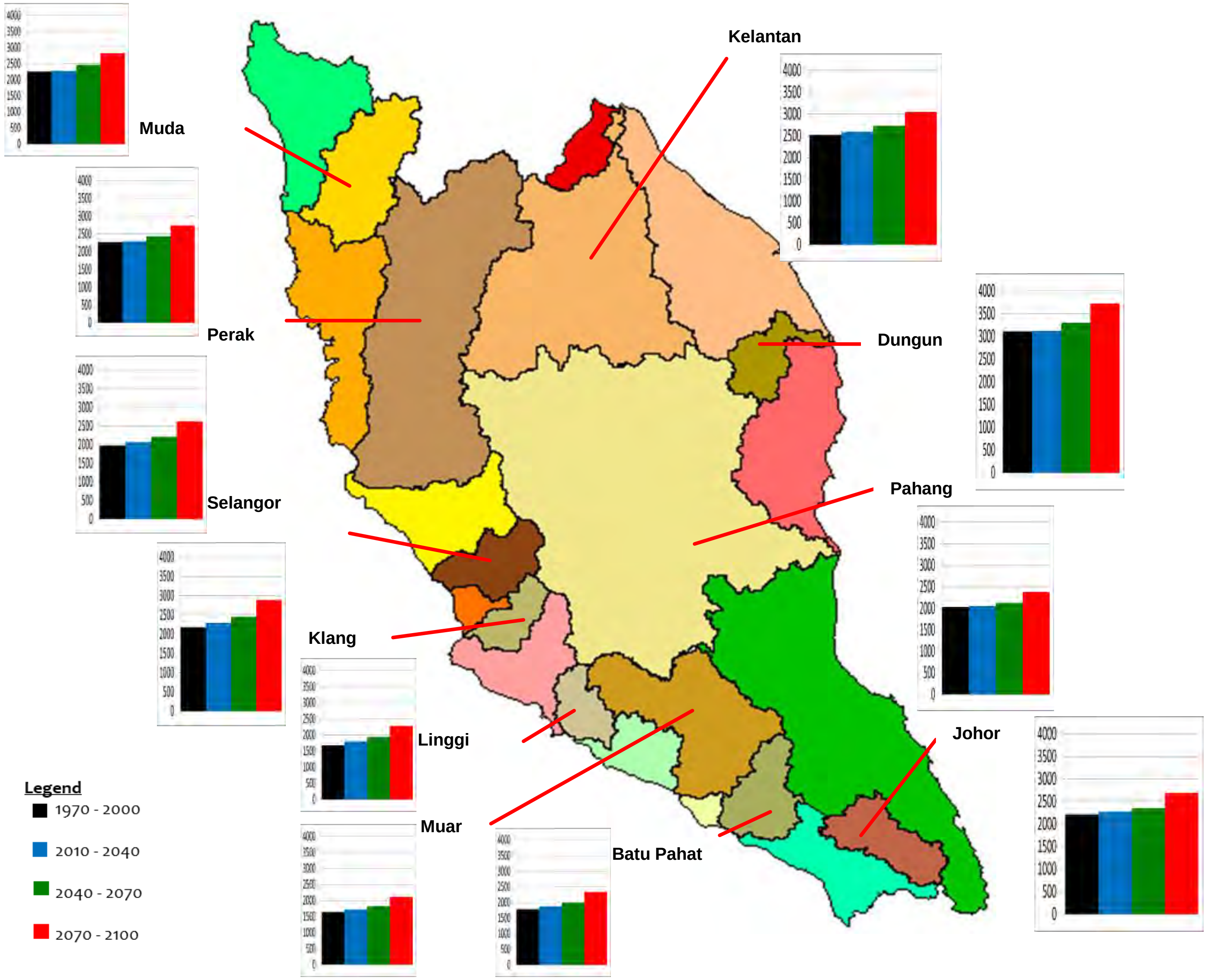
30-year Mean of Basin Average Annual Precipitation

Magnitude of Change

Period	30-yr Annual Precipitation	
	mm	%
2010-2040	12 - 121	0.4 - 6
2040-2070	96 - 278	5 - 13
2070-2100	348 - 714	17 - 33

11 catchments:
ranging from 1.0 – 1.36

12 coastal region:
ranging from 1.0 - 1.45



Source: NAHRIM, 2014

30-year Basin Average 1-Day Maximum Precipitation (NAHRIM, 2014)

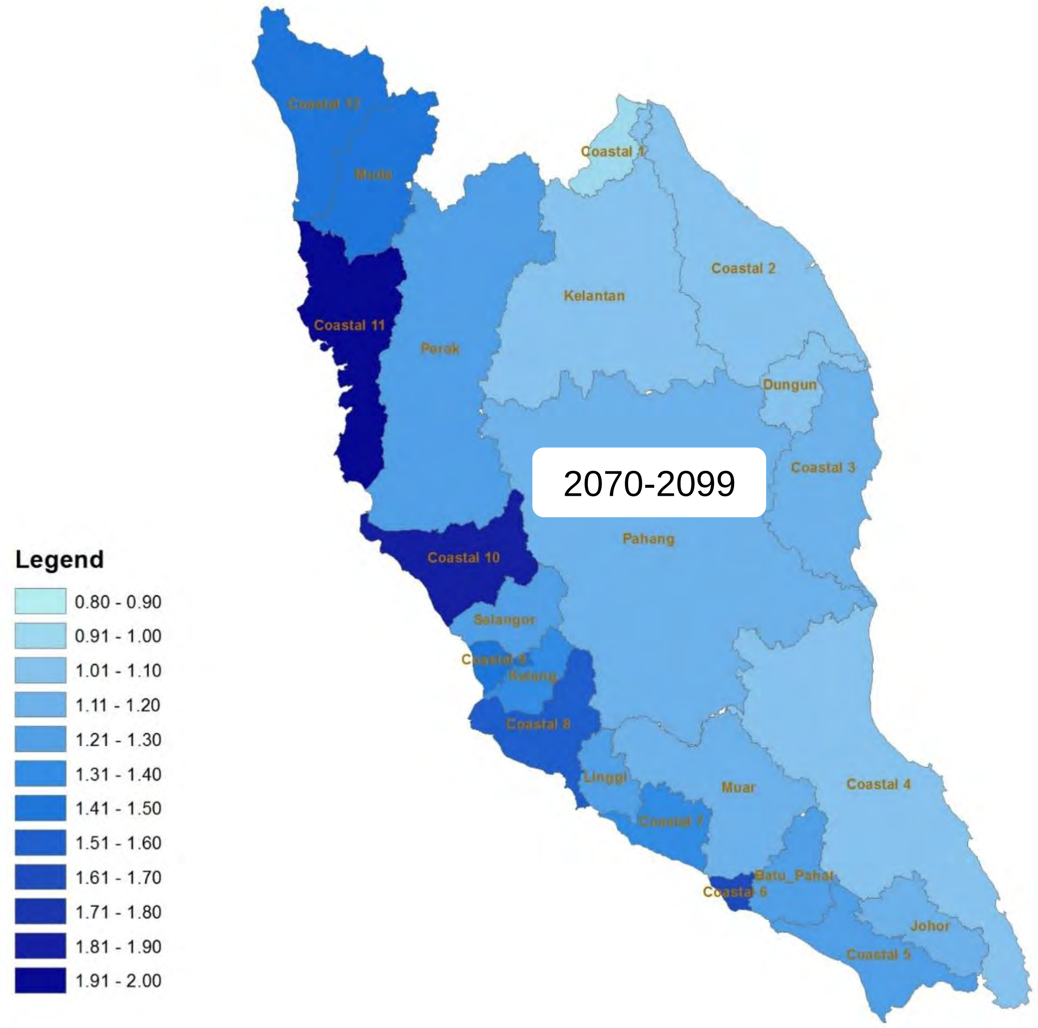
Magnitude of Change

11 WATERSHEDS

Period	30-yr Annual Precip.	
	mm	%
2010-2040	0 - 30	0 - 30
2040-2070	3 - 20	6 – 27
2070-2100	7 - 38	7 - 49

12 COASTAL REGIONS

Period	30-yr Annual Precip.	
	mm	%
2010-2040	0 - 40	0 - 75
2040-2070	2 - 52	2 – 79
2070-2100	6 - 77	5 - 92



Source: NAHRIM, 2014

Projected High and Low Flows by 2100 – Peninsular Malaysia

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

Source: NAHRIM, 2014

OUTLINE

- INTRODUCTION
- FLOOD AND CLIMATE SCENARIO
- SETTING THE CONTEXT - CLIMATE PROJECTION
- WATER PLANNING – FLOOD RISK MANAGEMENT
- CONCLUSION – KEY MESSAGE
- **WEB PORTAL** - HYDRO-CLIMATE DATA ANALYSIS ACCELERATOR

WATER PLANNING

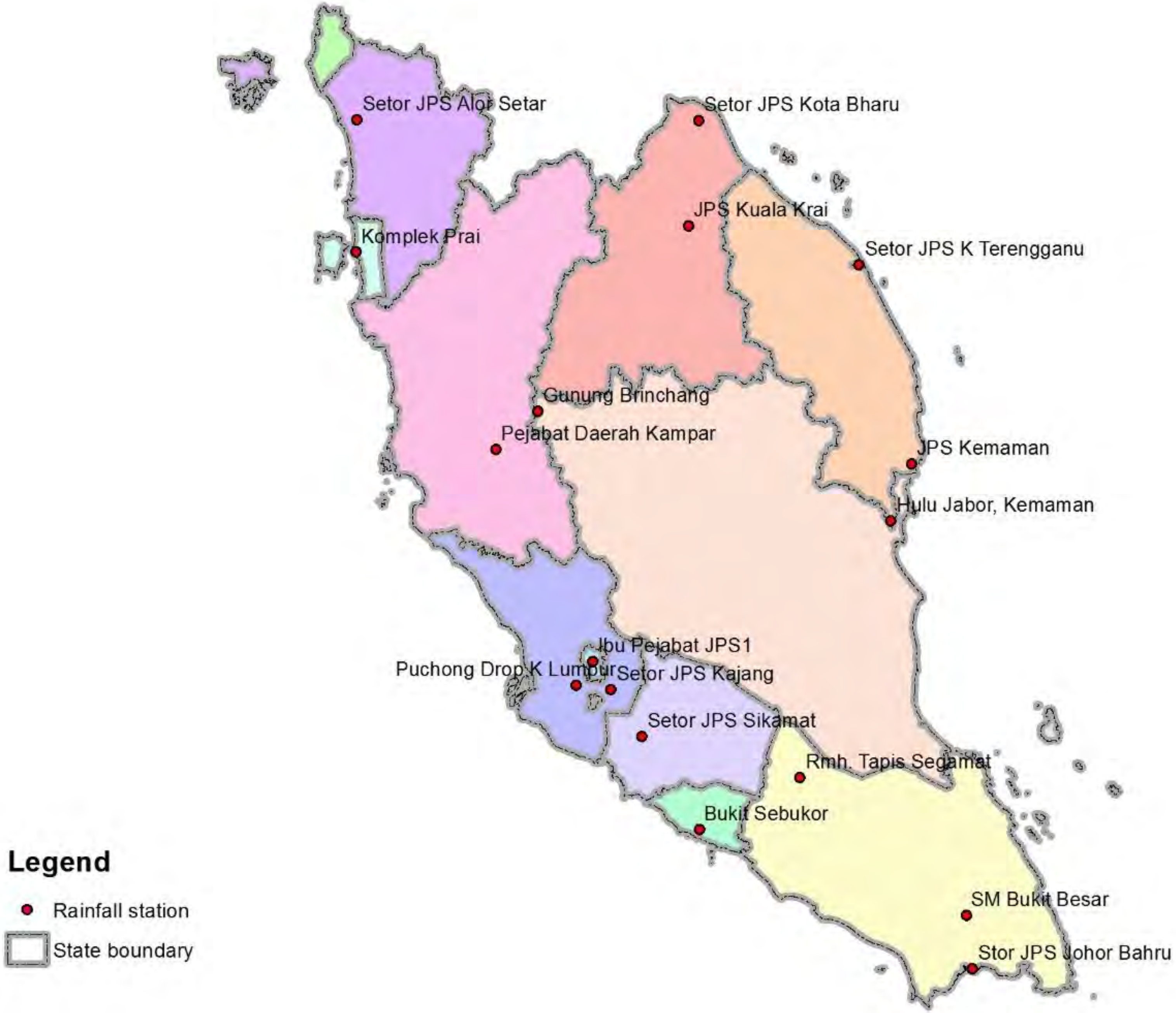
1. Planning for Water Resources Management

   Water supply/demand assumptions are developed to portray the expected envelope of supply variability suitable for the given planning horizon.

2. Planning for Infrastructure Safety and Flood Risk Reduction

   Infrastructure safety evaluations focus on rare events that could possibly cause facility failure and consequences that may include loss of life – climate change & variability

MAIN CONCERN:
DECLINING THE DEGREE OF SAFETY LEVEL



1-day 100-year Rainfall

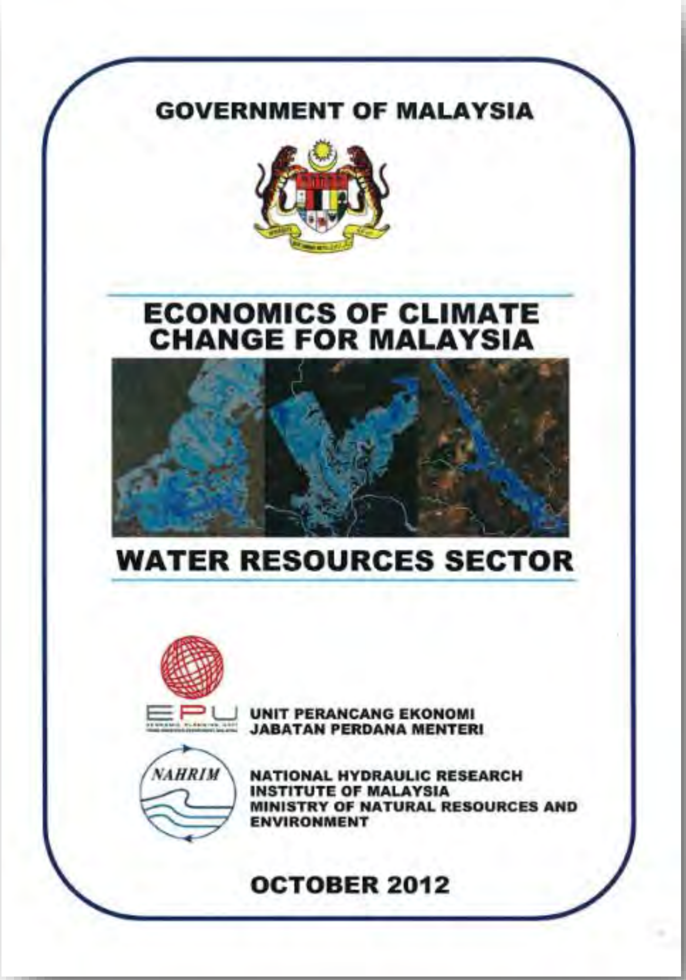
#
“Design storm is dead” (Sayers et al, 2015)

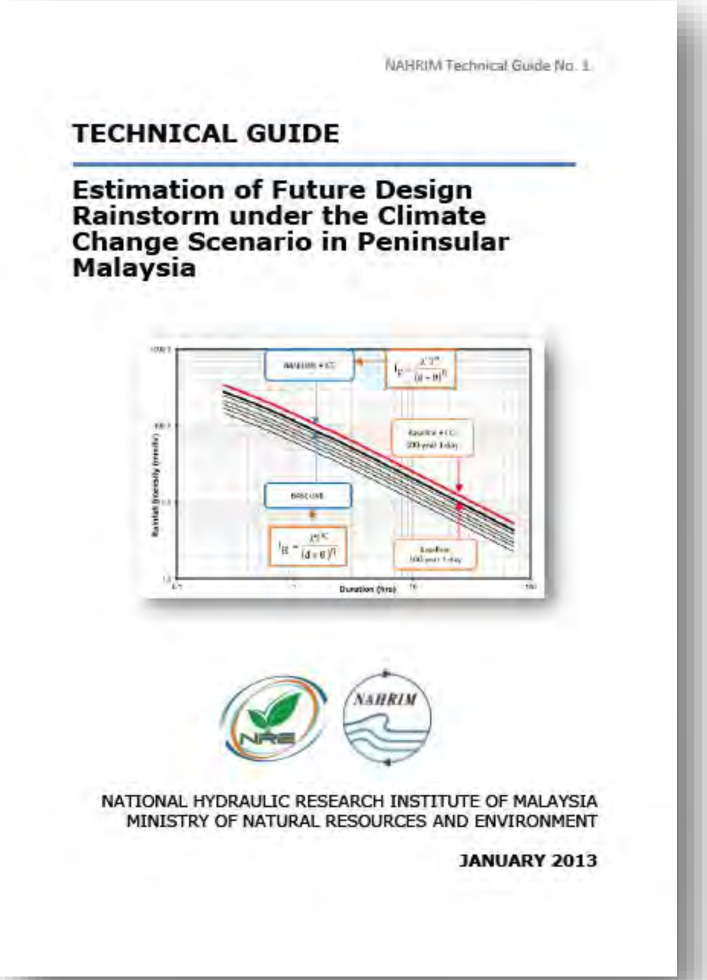
Storm sequences and clusters are important : repeat storms lowered beaches, weaken defences and lead failure

Station name	Rainfall depth (mm)	Rainfall intensity (mm/hr)	Return period (year)				
			x1.1	x1.2	x1.3	x1.4	x1.5
Pejabat Daerah Kampar	249	10.4	53	29	17	10	6
Setor JPS Kajang	225	9.4	55	32	20	12	8
Gunung Brinchang	167	7.0	56	33	20	13	8
Hulu Jabor	734	30.6	66	45	32	23	17
JPS Kemaman	536	22.3	62	40	27	19	13
Setor JPS K. Terengganu	629	26.2	64	42	29	20	15
JPS Kuala Krai	461	19.2	66	45	32	23	17
Setor JPS Kota Bharu	552	23.0	64	43	29	21	15
Bukit Sebukor	241	10.0	57	34	21	14	9
Komplek Prai	329	13.7	63	41	27	19	14
Setor JPS Alor Setar	262	10.9	58	34	21	14	9
Stor JPS Johor Bahru	244	10.2	56	33	20	13	8
Puchong Drop	203	8.5	53	30	18	11	7
Ibu Pejabat JPS1	214	8.9	51	29	17	10	7
Setor JPS Sikamat	207	8.6	57	34	21	13	9
SM Bukit Besar	296	12.4	61	39	26	17	12
Rmh. Tapis Segamat	317	13.2	65	44	31	22	16

......overcome major challenges in **a changing climate....**

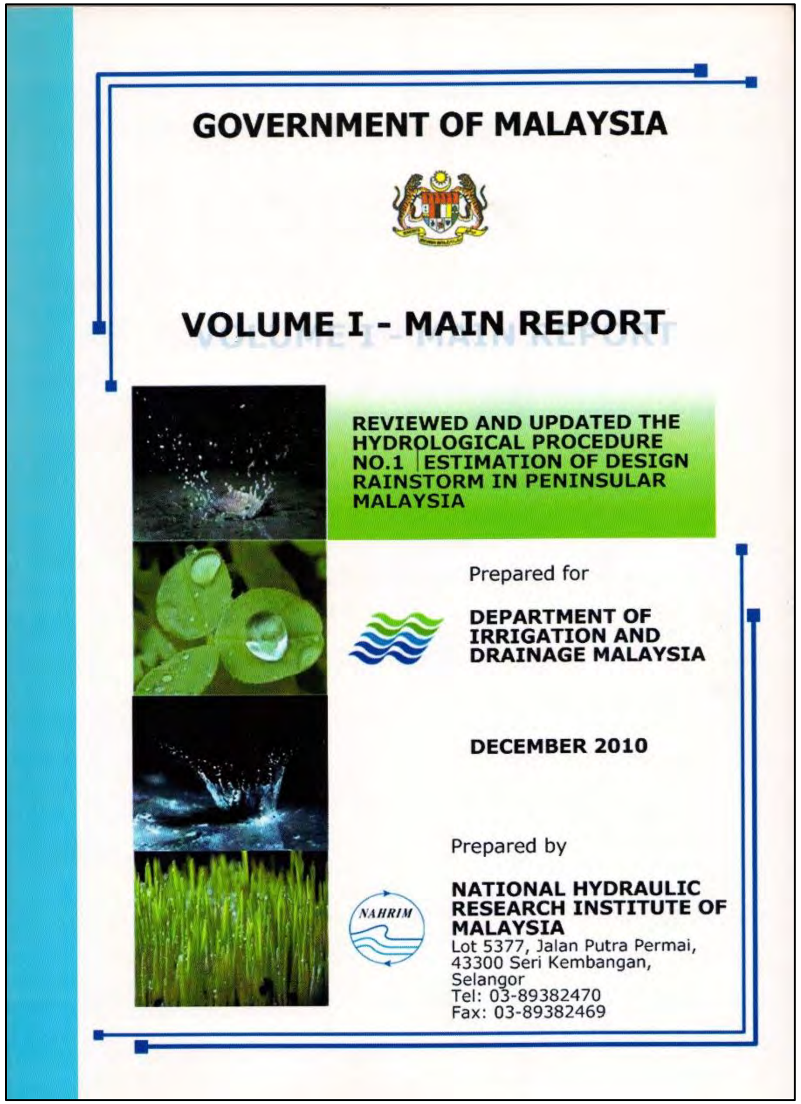
- How to integrate & coordinate issues of non-climatic and climatic forcing
- How to build resilience or adapt to climate change impacts
- Make decisions about how to use the Climate Change information


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

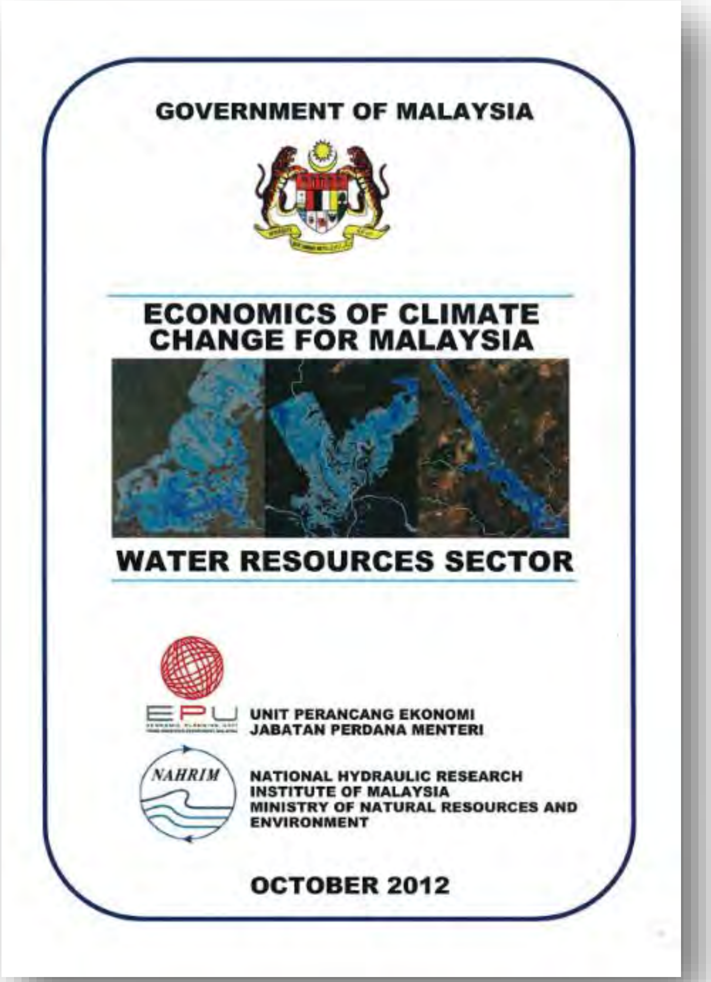

NAHRIM Technical Guide No. 1
TECHNICAL GUIDE
Estimation of Future Design Rainstorm under the Climate Change Scenario in Peninsular Malaysia
NATIONAL HYDRAULIC RESEARCH INSTITUTE OF MALAYSIA
MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT
JANUARY 2013

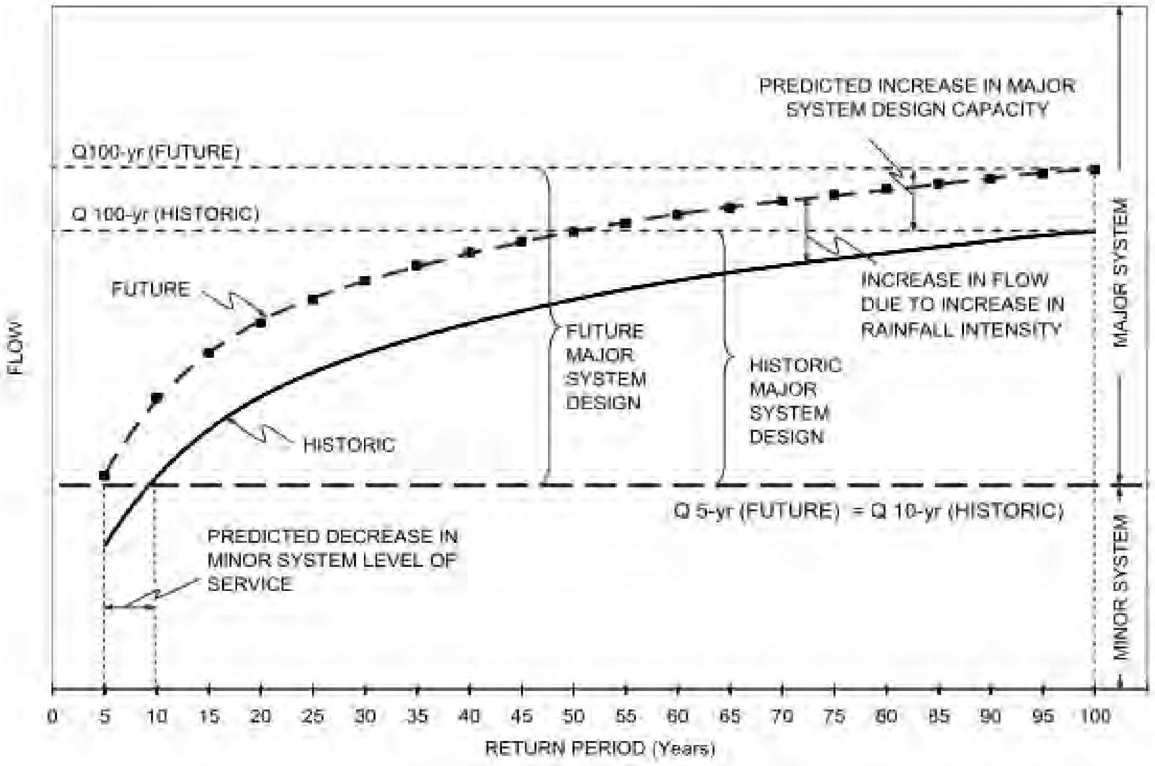

HP 26
HYDROLOGICAL PROCEDURE
ESTIMATION OF DESIGN RAINSTORM IN SABAH AND SARAWAK
(REVISED AND UPDATED 2018)
DEPARTMENT OF IRRIGATION AND DRAINAGE MALAYSIA


HP 26
HYDROLOGICAL PROCEDURE
ESTIMATION OF DESIGN RAINSTORM IN SABAH AND SARAWAK
(REVISED AND UPDATED 2018)
FINAL REPORT
VOLUME I
DEPARTMENT OF IRRIGATION AND DRAINAGE MALAYSIA


GOVERNMENT OF MALAYSIA
VOLUME I - MAIN REPORT
REVIEWED AND UPDATED THE HYDROLOGICAL PROCEDURE NO.1 ESTIMATION OF DESIGN RAINSTORM IN PENINSULAR MALAYSIA
Prepared for
DEPARTMENT OF IRRIGATION AND DRAINAGE MALAYSIA
DECEMBER 2010
Prepared by
NATIONAL HYDRAULIC RESEARCH INSTITUTE OF MALAYSIA
Lot 5377, Jalan Putra Permai,
43300 Seri Kembangan,
Selangor
Tel: 03-89382470
Fax: 03-89382469
NAHRIM

FORMULATION OF FLOOD RISK ASSESSMENT UNDER THE CHANGING CLIMATE





- BASELINE: costs of providing flood mitigation based in 2050, WITHOUT CLIMATE CHANGE.
- BASELINE AND CLIMATE CHANGE: assumes that the costs of adaptation in the baseline will increase or decrease by the same percentage as the percentage change in magnitude of the 100-year
- CLIMATE CHANGE ONLY (CC): difference between baseline and baseline & CC scenario.

Pen Malaysia: Climate Change Factor (CCF)


NAHRIM Technical Guide No. 1

TECHNICAL GUIDE

Estimation of Future Design Rainstorm under the Climate Change Scenario in Peninsular Malaysia

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

JANUARY 2013

- defined as the ratio of the design rainfall for each of the future periods (time horizons) to the control periods (present rainfall)

$$CCF_{1d}^{T} = \frac{{}_{SF}R_{1d}^{T}}{{}_{SH}R_{1d}^{T}}$$

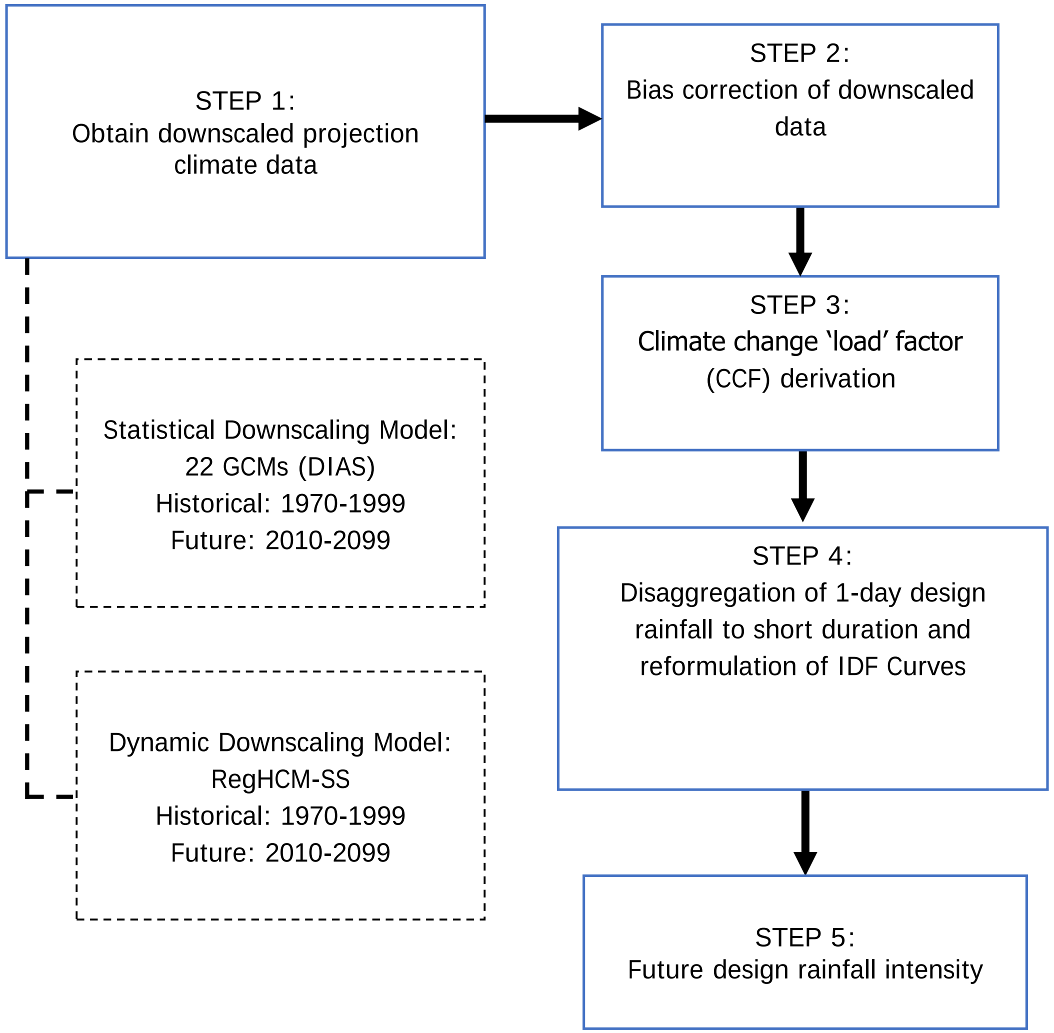
where

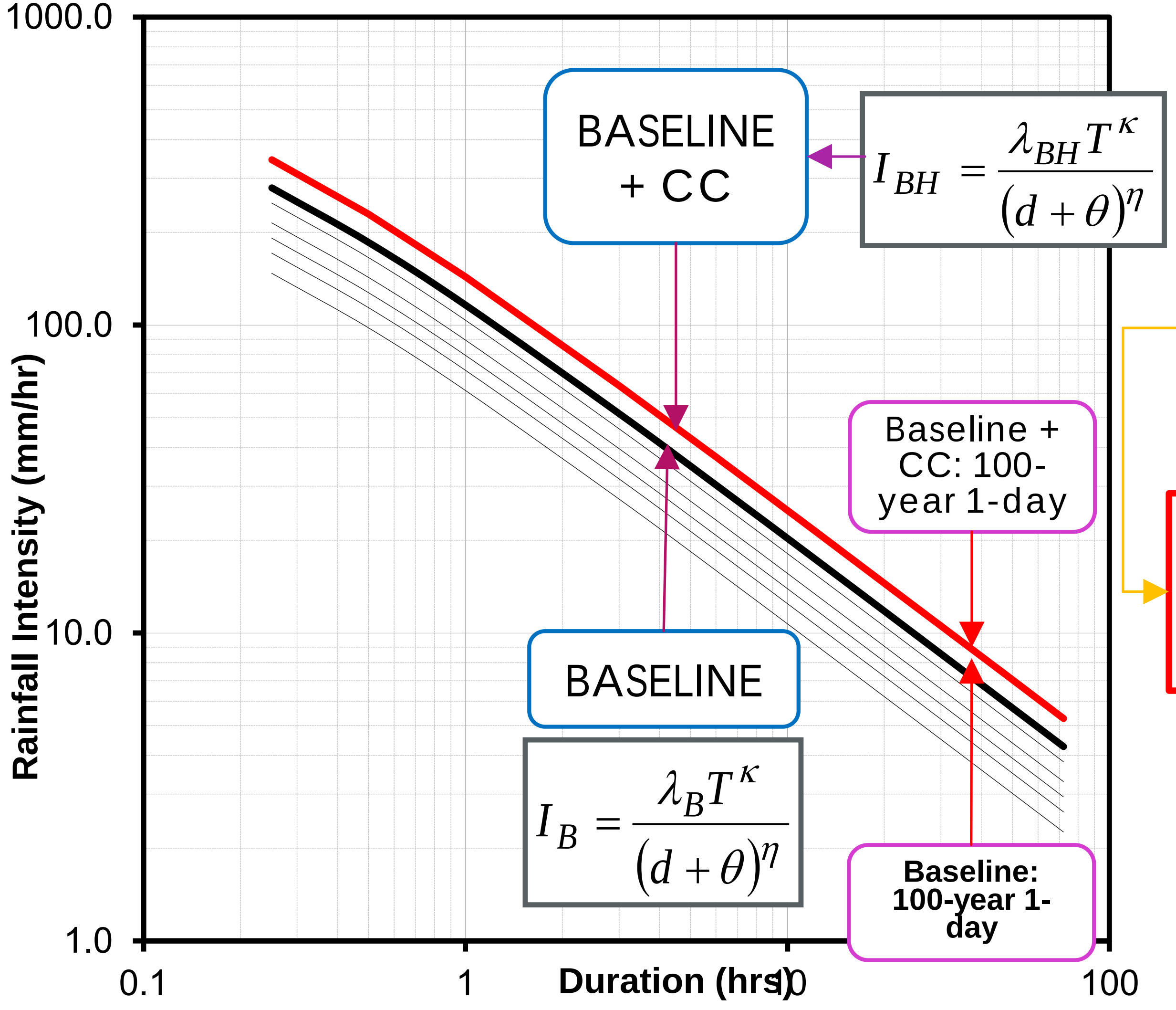
${}_{SF}R_{1d}^{T}$ = simulated future 1-day design rainfall
${}_{SH}R_{1d}^{T}$ = simulated historical 1-day design of control period

- Based on 2006 RegHCM-PM data & 18 statistically downscaled GCMs
- Embedded in DID Hydrological Procedure No. 1

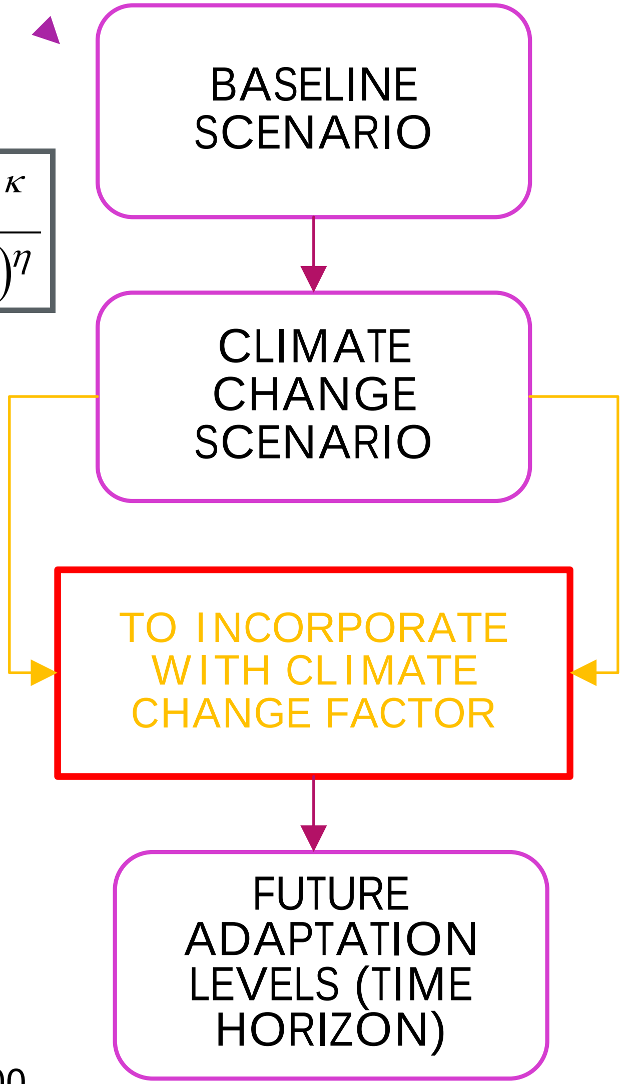
Sabah & Sarawak : Developing the Climate Change Factor (CCF)

- Derivation of CCF is based on IPCC AR4 A_1B scenario.
- Three interpolated maps are produced based on GCMs (24nos) projected data combinations:
  a) Average of IPCC AR4 A_1B ECHAM5 (ECHAM5_1, ECHAM5_2, ECHAM5_3)
  b) Average of IPCC AR4 A_1B ECHAM5 and MRI
  c) Average of IPCC AR4 A_1B ECHAM5, MRI and 22 GCMs
- Combination option (c) was selected since it utilizes all the scenarios from both DIAS (22 GCMs) and RegHCM (2GCMs) database. The produced results are more accurate than other GCM combinations.





1000.0
100.0
10.0
1.0
0.1
1
10
100
Rainfall Intensity (mm/hr)
Duration (hrs)
BASELINE + CC
$I_{BH} = \frac{\lambda_{BH} T^{\kappa}}{(d+\theta)^{\eta}}$
Baseline + CC: 100-year 1-day
BASELINE
$I_B = \frac{\lambda_B T^{\kappa}}{(d+\theta)^{\eta}}$
Baseline: 100-year 1-day



BASELINE SCENARIO
CLIMATE CHANGE SCENARIO
TO INCORPORATE WITH CLIMATE CHANGE FACTOR
FUTURE ADAPTATION LEVELS (TIME HORIZON)

ANALYSIS OUTCOME: WATER RESOURCES SECTOR

DESIGNED FLOOD PEAKS – SG KEDAH

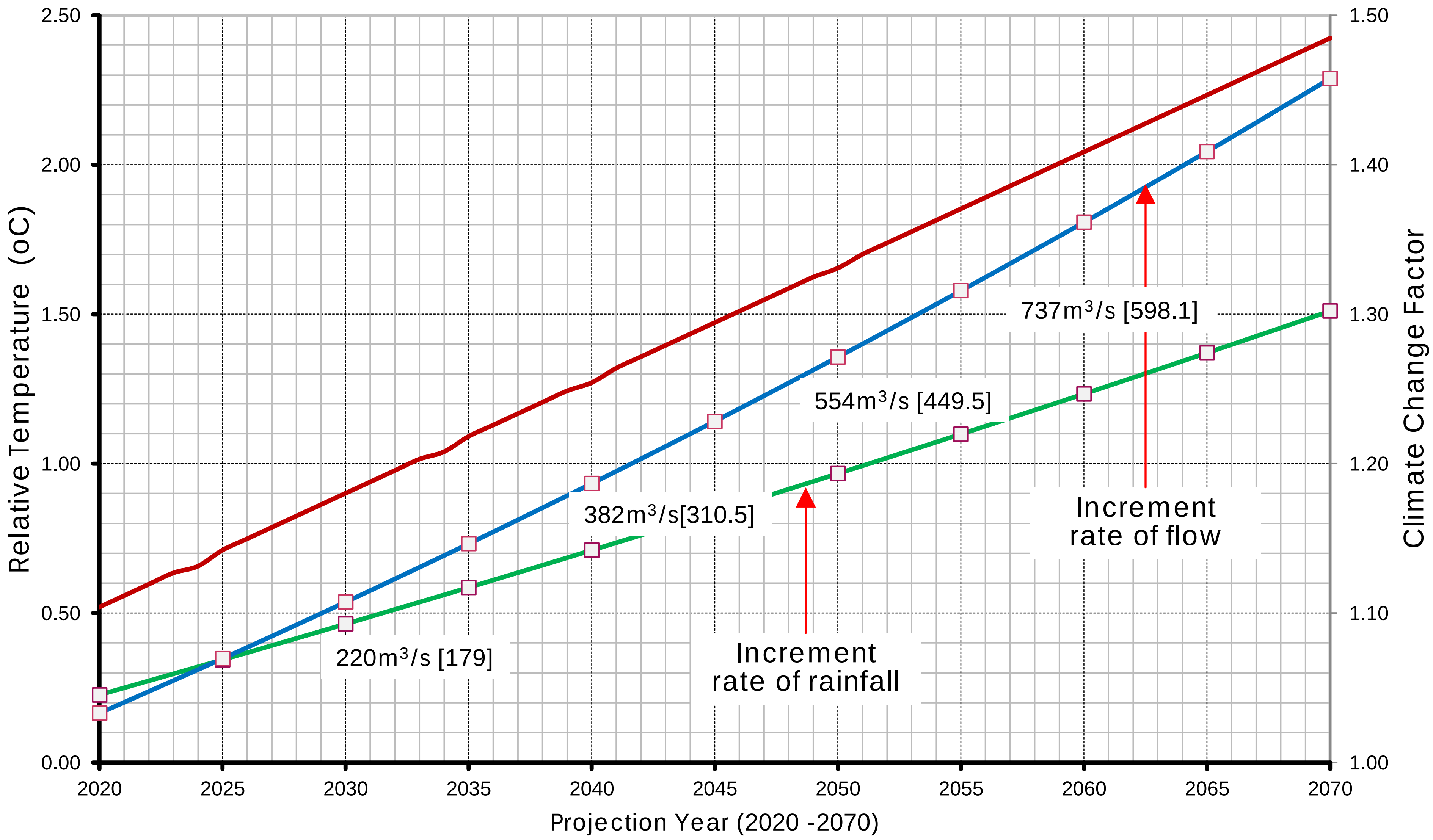
(a) Item	(b) Time Horizon	(c) Climate Change Factor (CCF)	100-Year ARI			
			(d) 1-Day Design Rainfall (Baseline= 240.6 mm)	Simulated Flood Magnitude, Qp (Baseline= 2047.9m^3/s)		
				(e) Baseline & Future Landuse Scenario	(f) Baseline & Climate Change Scenario	(g) Baseline & Climate Change with Future Landuse Scenario
1	2020	1.05	245.2	2202.6 [154.7]	2111.2 [63.3]	2313.7 [265.8]
2	2030	1.09	256.5	2209.0 [161.1]	2267.9 [220.0]	2438.0 [390.1]
3	2040	1.14	268.0	2215.9 [168.0]	2430.2 [382.3]	2613.8 [565.9]
4	2050	1.19	280.0	2223.1 [175.2]	2601.9 [554.0]	2799.9 [752.0]
5	2060	1.25	292.6	2230.1 [182.2]	2785.3 [737.4]	2997.6 [949.7]

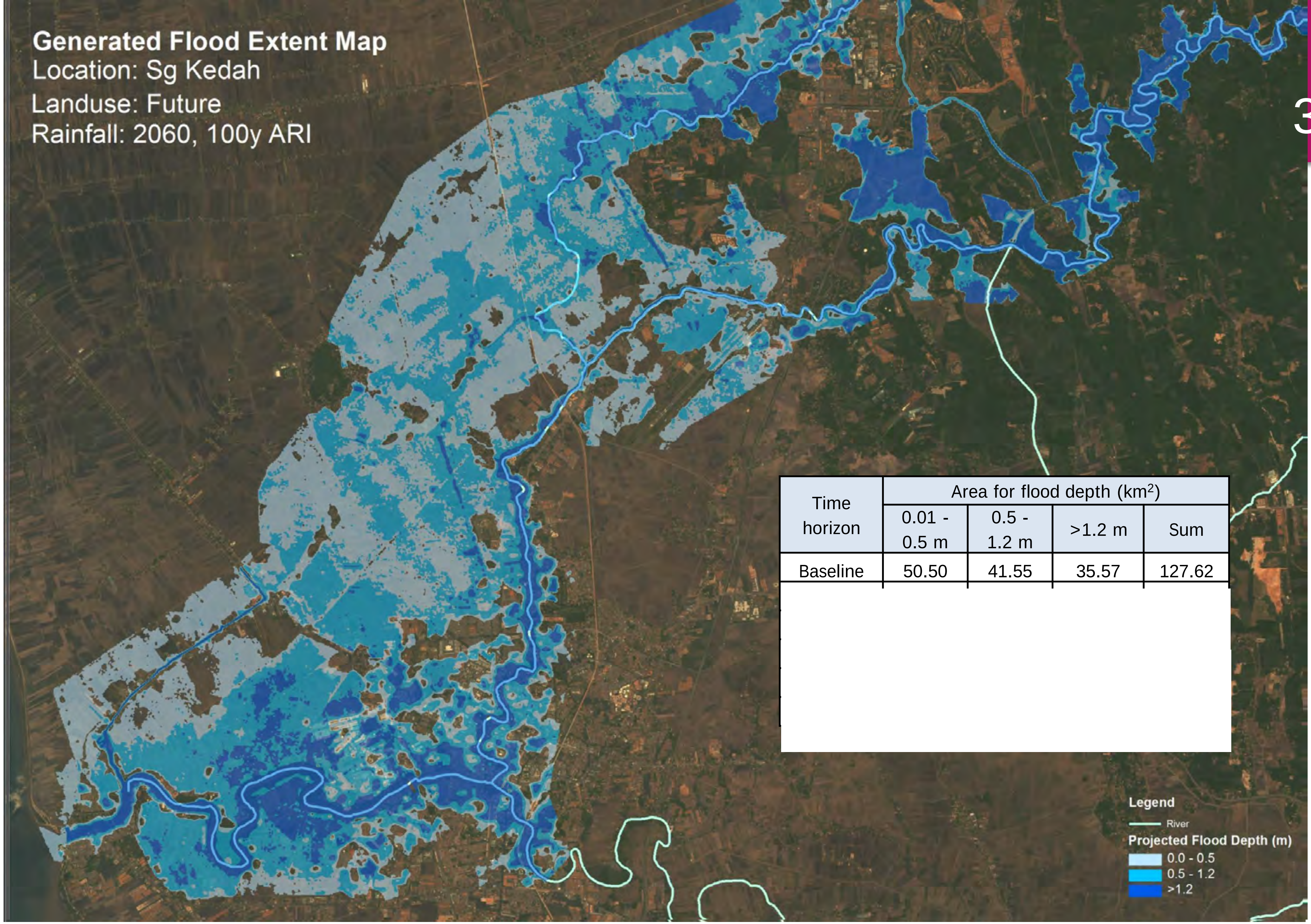
Note: [ ] – flood magnitudes adaptation value

(a) Item	(b) Time Horizon	(c) Climate Change Factor (CCF)	Peak Discharges (Q) 100 years ARI for Sungai Kedah				
			(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 (m3/s)	(g) Discharge Ratio	(h) Discharge per Area (m3/s/km2)
1	2020	1.05	245.2	2111.2	63.3[3.1]#	1.03	0.75
2	2030	1.09	256.5	2267.9	220.0[10.7]	1.11	0.81
3	2040	1.14	268.0	2430.2	382.3[18.7]	1.19	0.87
4	2050	1.19	280.0	2601.9	554.0[27.1]	1.27	0.93
5	2060	1.25	292.6	2785.3	737.4[36.0]	1.36	0.99

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

Projected Daily Annual Mean Surface Temperature for Malaysia & Climate Change Factor of Sungai Kedah



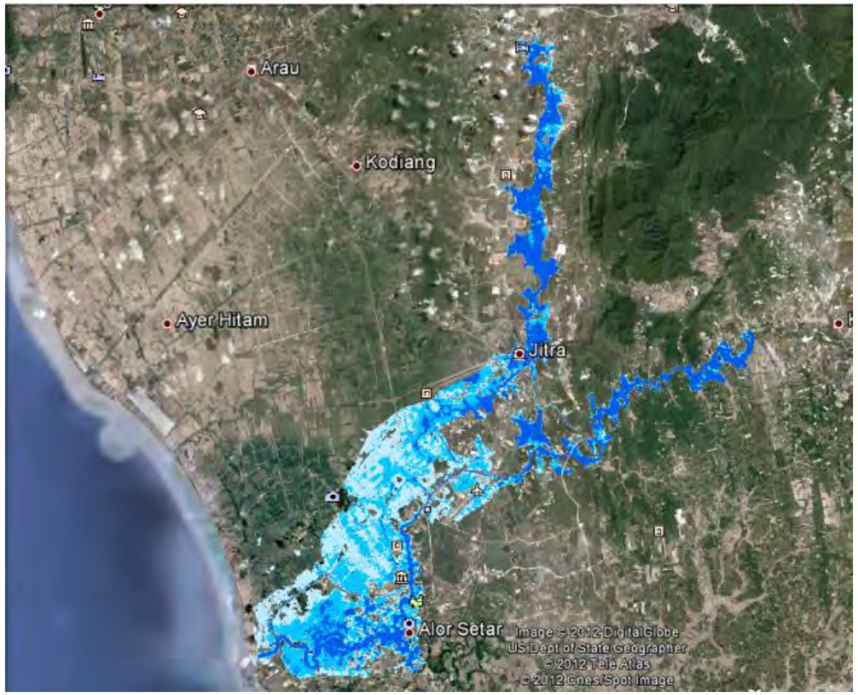


Time horizon	Area for flood depth (km²)			
	0.01 - 0.5 m	0.5 - 1.2 m	>1.2 m	Sum
Baseline	50.50	41.55	35.57	127.62

Flood Damages: Baseline and Future (Climate Change Impact)

Baseline (Sungai Kedah, 100 years ARI)

2060 (Sungai Kedah, 100 years ARI)



Flood Inundated Area by Flood Depth Sungai Kedah Basin

flood depth	Sungai Kedah (area of flood depth, km2)	
	Baseline	2060
0.0 - 0.5 m	50.5	48.16
0.5 - 1.2 m	41.55	50
>1.2 m	35.57	46.95
Total	127.62	145.11

Impact of Floods in the Sg 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**

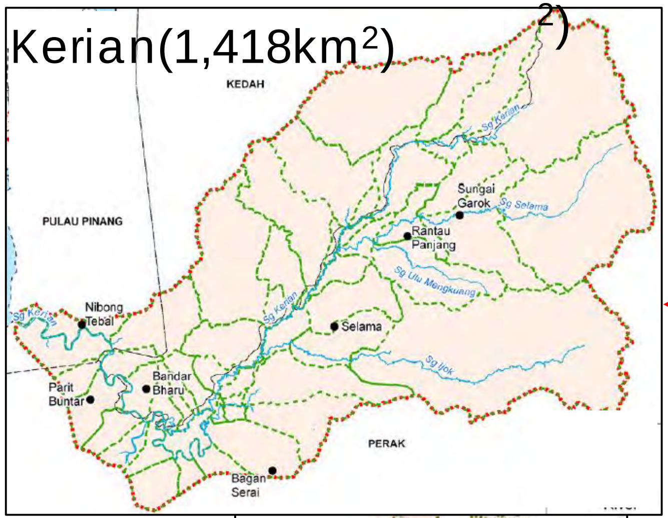
- The total flood damage for this flood episode was 2.7% of Kedah's GDP.
- Damage to the paddy sector was 4.2% to the state's Agriculture sector GDP.
- In terms of the service sector, the estimate is 2.4% loss of output, based on the 2010 GDP structure for Kedah.

By 2060

- The worst flood impact arising from the change in climate factors would increase from 2.7% in 2010 to 6.8% in 2060.
- Damage to the agricultural sector will rise from 4.2% to 13.5% if paddy planting were maintained at current levels.

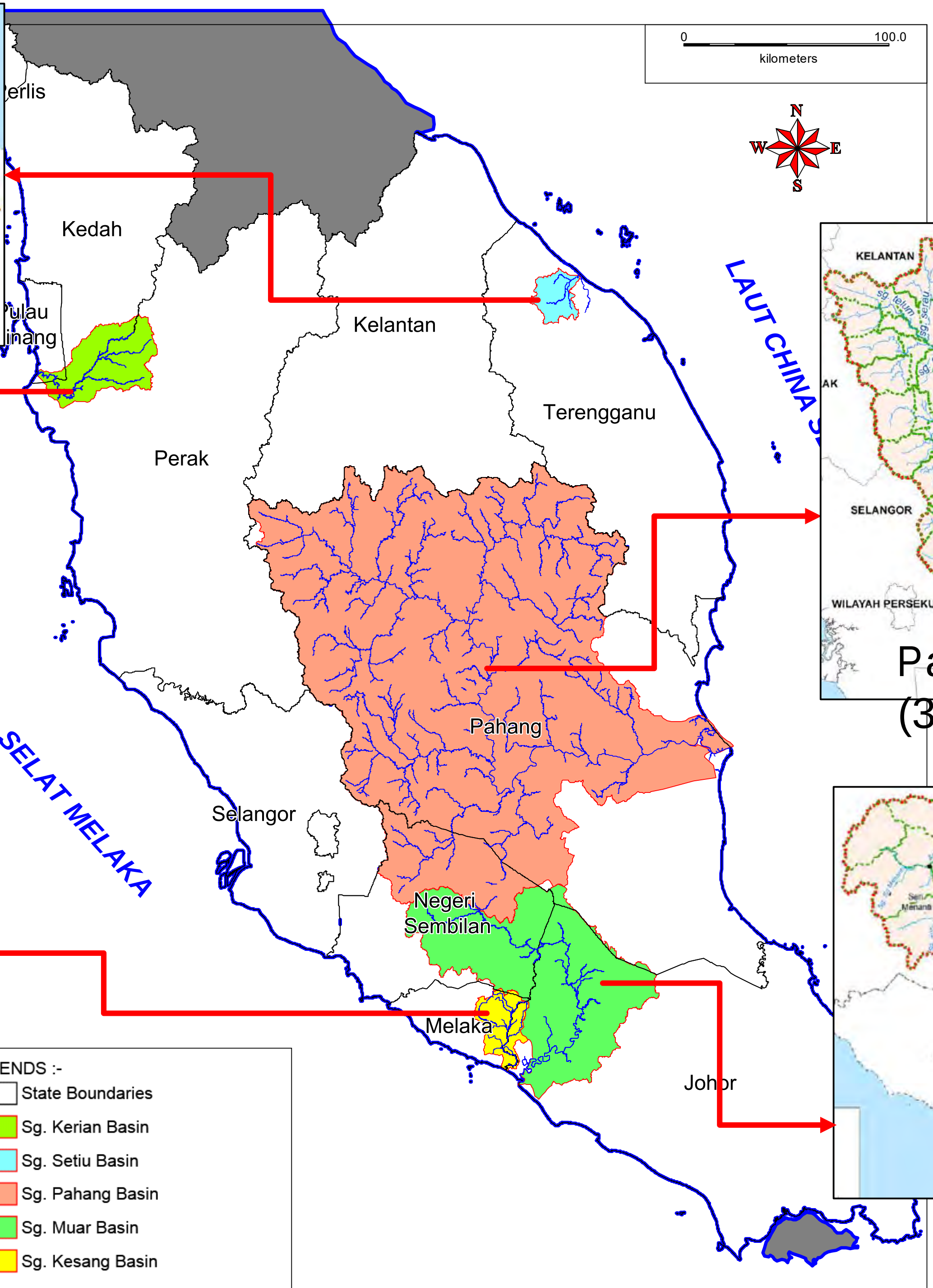
- ❑ 5 river basins
- ❑ Continuation of ECCM study (2012)

Setiu(1,035km^2)



Kerian(1,418km^2)

Kesang(696.40km^2)



Pahang (30,000km^2)

Muar(6,149km^2)

Setiu River Basin

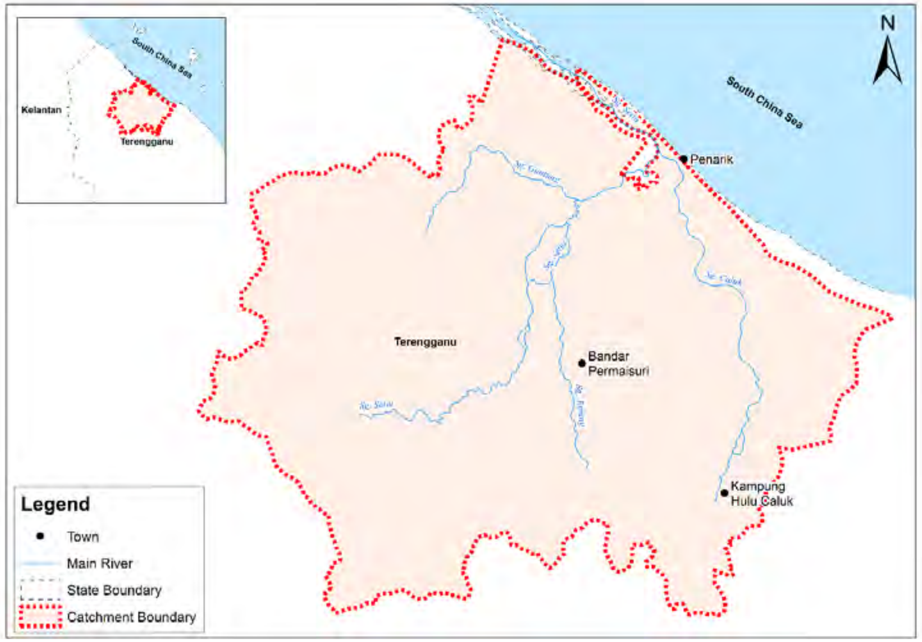
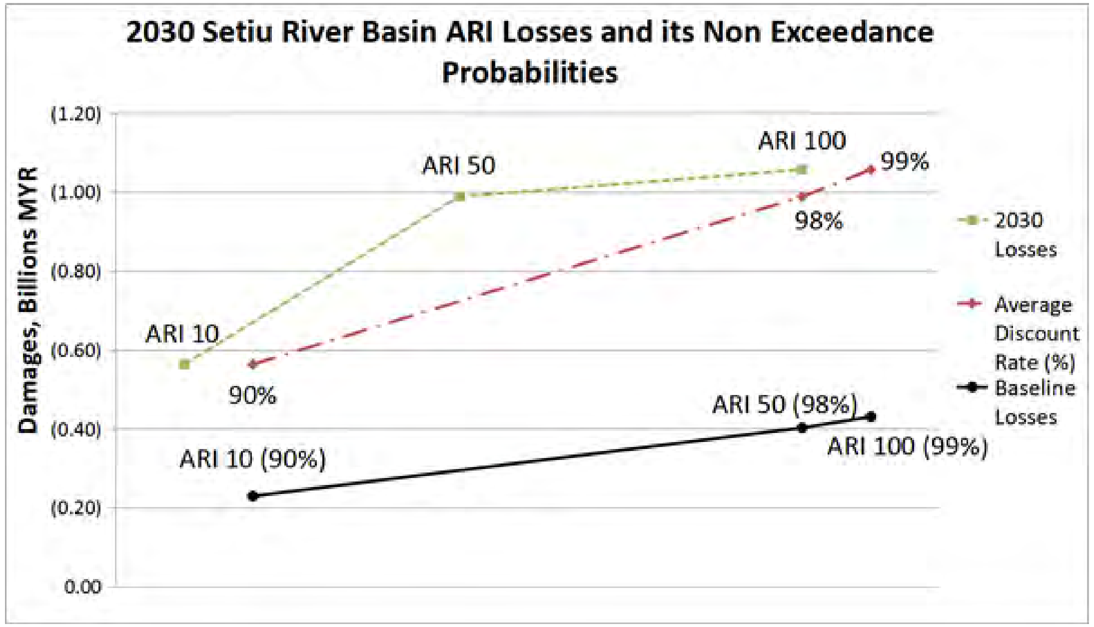


Table 4.14: Minimum Flood Losses for different ARI categories

ARI (year)	10	50	100
Baseline losses	16,055,547	20,054,641	20,062,615
2030 Scenario	39,396,561	49,209,402	49,228,968
2050 Scenario	169,311,976	211,862,441	213,894,254

	BASELINE	2030	2050
	Percentage	Percentage	Percentage
Residential Houses	35.7%	31.7%	32.5%
Government Building	1.7%	1.6%	1.6%
Agricultural Sector	5.0%	4.3%	4.5%
Public Infrastructure	0.6%	0.5%	0.5%
Commercial Building	57.0%	61.8%	60.9%



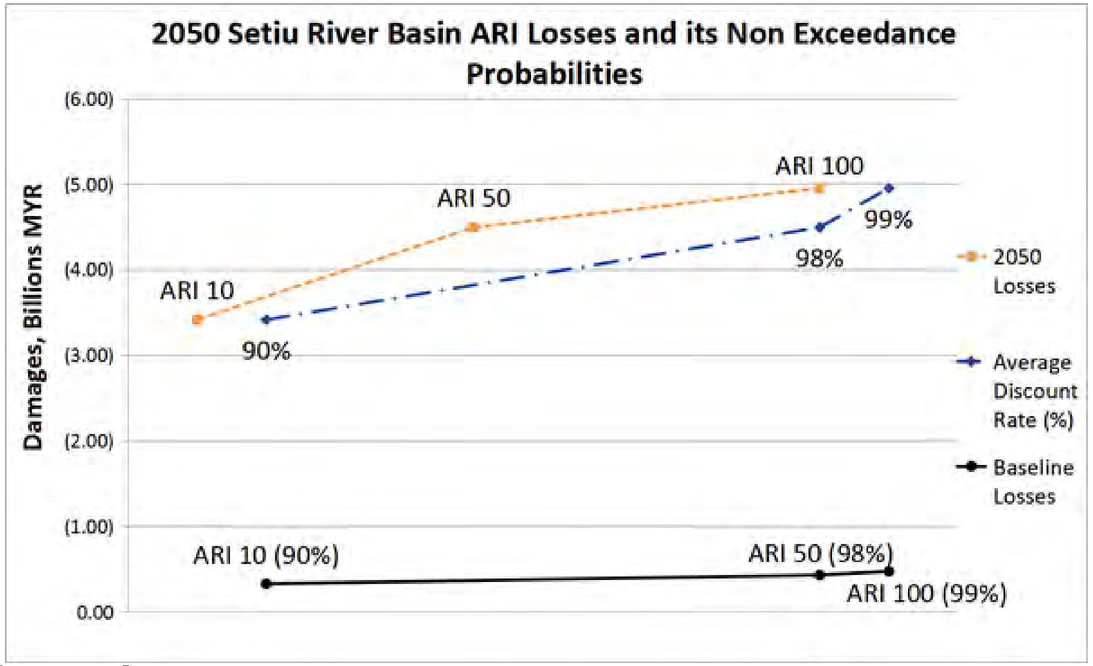


Table 4.16: The Percentage Distribution of Assets Losses

Pahang River Basin

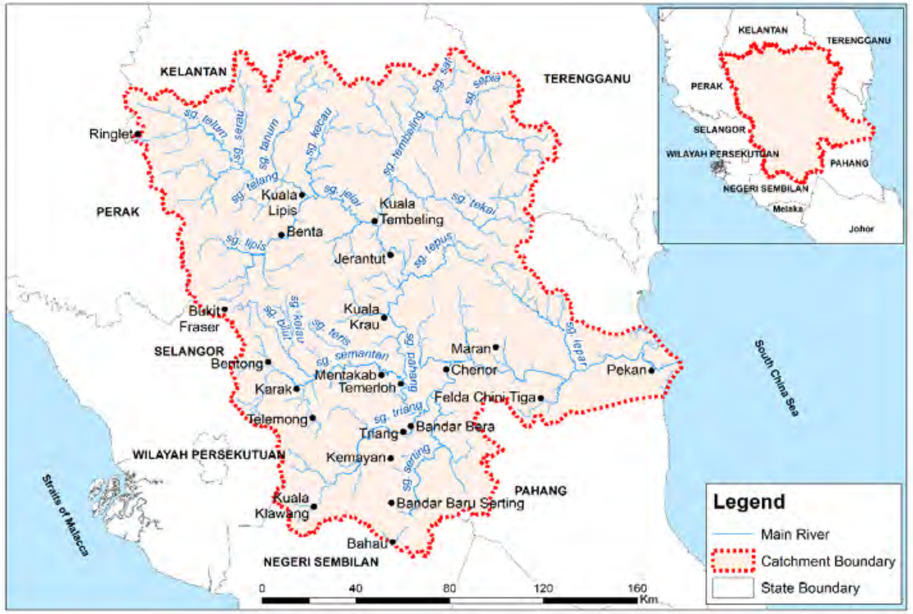
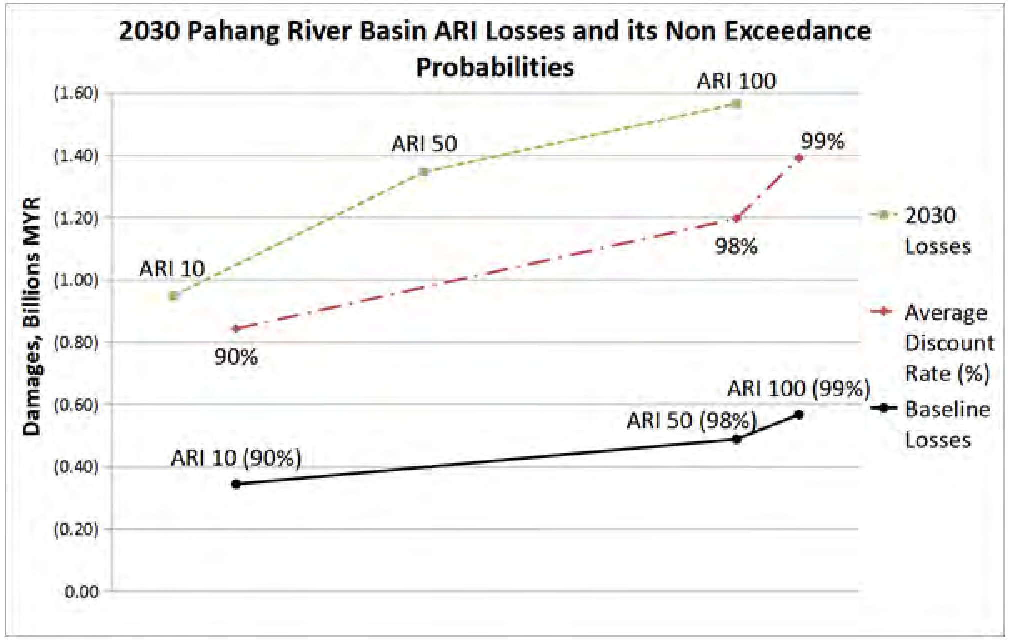


Table 4.18: Minimum Financial Losses (baseline) for different ARI categories

ARI (year)	10	50	100
Baseline losses	386,509,467	548,600,150	637,812,190
2030 Scenario	948,403,887	1,346,136,534	1,565,042,028
2050 Scenario	5,865,498,764	7,756,805,896	11,499,394,356

	BASELINE	2030	2050
	Percentage	Percentage	Percentage
Residential Houses	40.0%	36.7%	23.4%
Schools/ Universities	0.2%	0.2%	0.1%
Government Building	0.8%	0.9%	0.5%
Agricultural Sector	3.3%	2.7%	1.6%
Public Infrastructure	0.6%	0.5%	0.3%
Commercial Building	55.0%	59.1%	74.0%

Table 4.20: The Percentage Distribution of Assets Losses



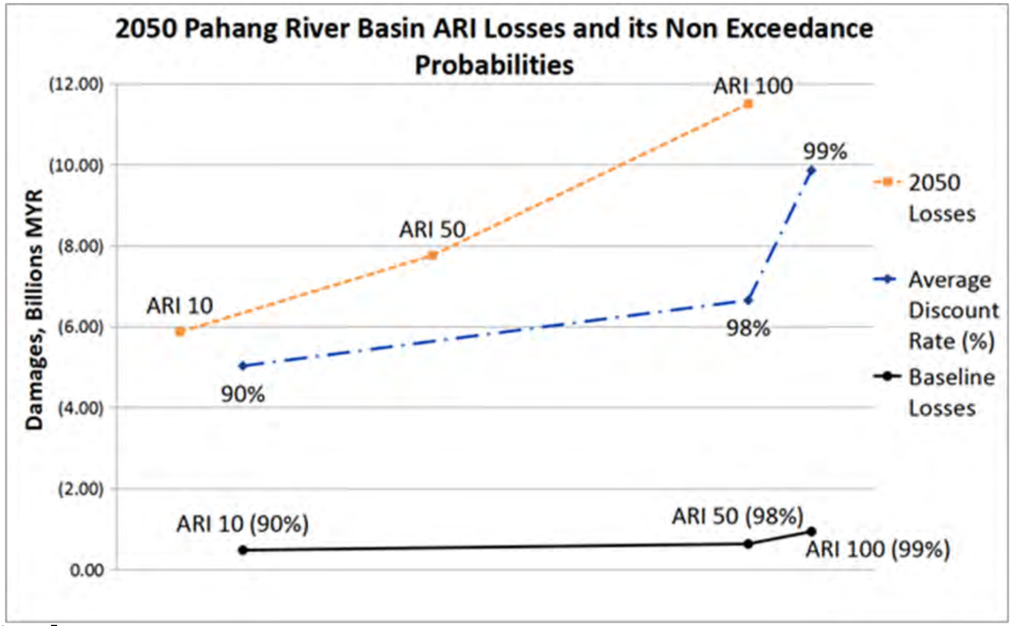
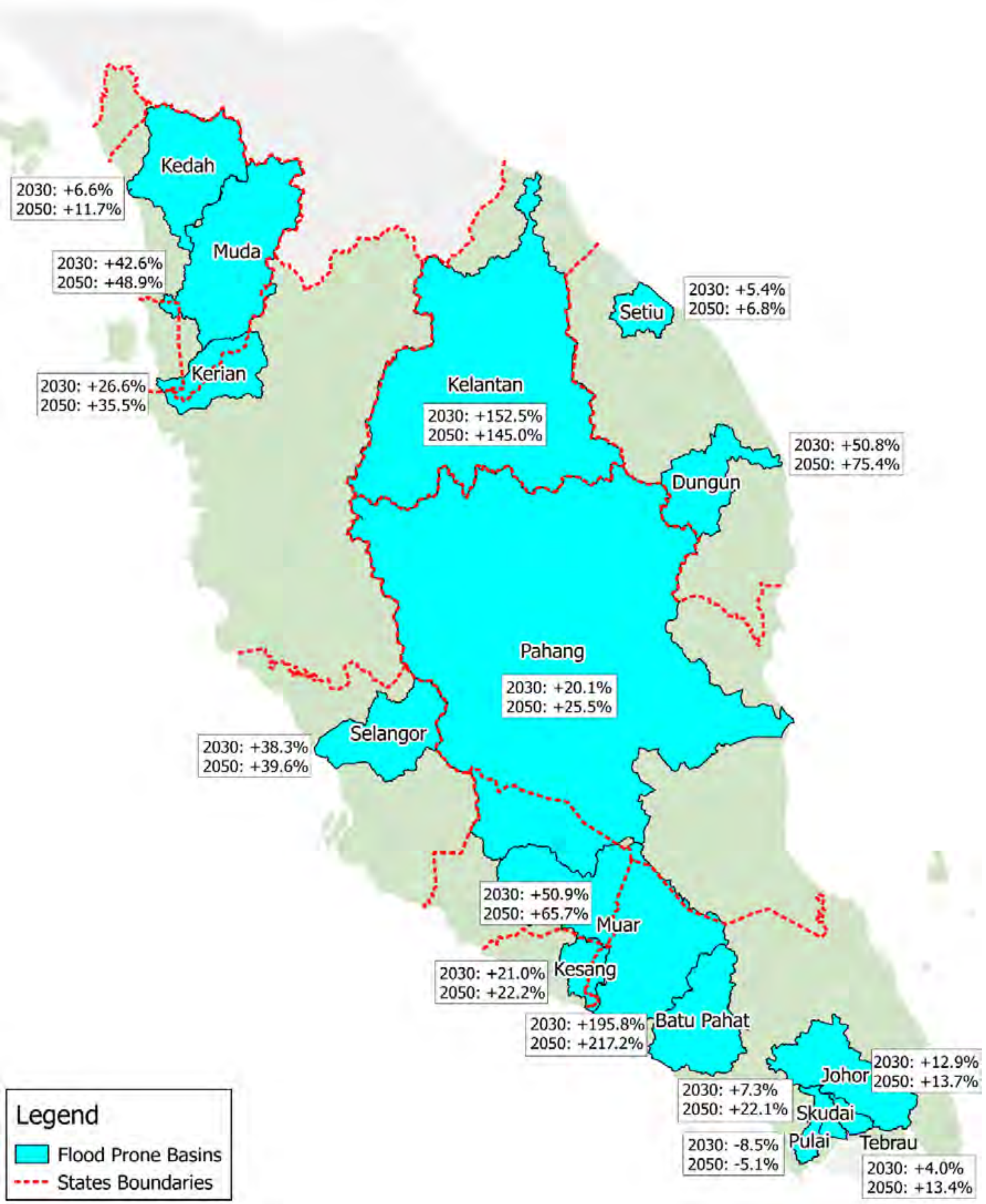


Table 5.1: Annual Average Damage (AAD) Summary of Five River Basins

Basin Name	AAD (2030)	AAD (2050)
Muar	MYR 18.2 Million	MYR 131 Million
Kesang	MYR 4.6 Million	MYR 20 Million
Kerian	MYR 87 Million	MYR 481 Million
Setiu	MYR 6.9 Million	MYR 29.6 Million
Pahang	MYR 137 Million	MYR 857 Million
Total:	**MYR 253.7 Million**	**MYR 1.5 Billion**

- Worst hit basin - Pahang River Basin followed by Kerian River Basintt
- The flood claim values used by this study were only conservative estimates at current market values
- Intangible damages and severe total loss scenarios are not considered under this study

Projected Changes in Flood Areal Extent for the Selected 15 Flood Prone Basins in Peninsular Malaysia



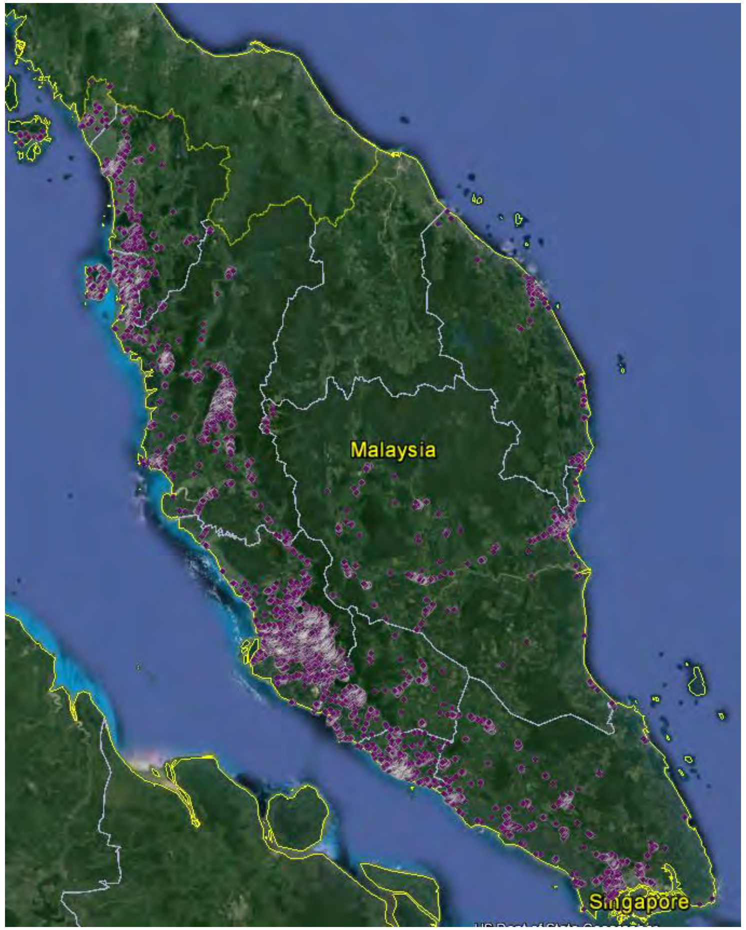
Projected Flood prone areas for the 15 basins in current, 2030 and 2050

Flood Prone Basins	Basin Area	Current Flood Prone Area	Projected Flood Prone Area (2030)		Projected Flood Prone Area (2050)	
	km^2	km^2	km^2	Changes (%)	km^2	Changes (%)
Kedah	2800	127.6	136.1	+6.6	142.5	+11.7
Kerian	1418	138.2	175.0	+26.6	187.3	+35.5
Kesang	696	89.1	107.8	+21.0	108.8	+22.2
Muar	6149	302.2	456.0	+50.9	500.6	+65.7
Pulai	280	16.9	15.5	-8.5	16.0	-5.1
Skudai	347	9.0	9.7	+7.3	11.0	+22.1
Tebrau	261	3.2	3.3	+4.0	3.6	+13.4
Pahang	28549	1403.8	1686.4	+20.1	1762.3	+25.5
Setiu	1035	123.4	130.0	+5.4	131.8	+6.8
Muda	4185	366.0	522.0	+42.6	545.0	+48.9
Selangor	2086	224.9	311.1	+38.3	314.0	+39.6
Batu Pahat	2233	209.8	620.6	+195.8	665.4	+217.2
Johor	2252	238.5	269.3	+12.9	271.1	+13.7
Dungun	1714	114.5	172.6	+50.8	200.9	+75.4
Kelantan	11901	551.0	1391.5	+152.5	1350.1	+145.0
TOTAL	**65,906**	**3,918**	**6,007**	**+9.1**	**6,210**	**+9.4**

PLANNING, MITIGATION ACTION AND ADAPTIVE CAPACITY NEED TO PUT IN PLACE.

RESERVOIR STORAGE AND DAM SECURITY

WATER SUPPLY – WATER TREATMENT PLANTS



WATER SANITARY – SEWERAGE TREATMENT PLANTS

CHAPTER

4

ASSESSMENT OF VULNERABILITY AND ADAPTATION

MALAYSIA

THIRD NATIONAL COMMUNICATION AND ECOND BIENNIAL UPDATE REPORT TO THE UNFCCC

BERSEKUTU BERTAMBAH MUTU

OUTLINE

- INTRODUCTION
- FLOOD AND CLIMATE SCENARIO
- SETTING THE CONTEXT - CLIMATE PROJECTION
- WATER PLANNING – FLOOD RISK MANAGEMENT
- CONCLUSION – KEY MESSAGE
- WEB PORTAL - HYDRO-CLIMATE DATA ANALYSIS ACCELERATOR

KEY MESSAGE

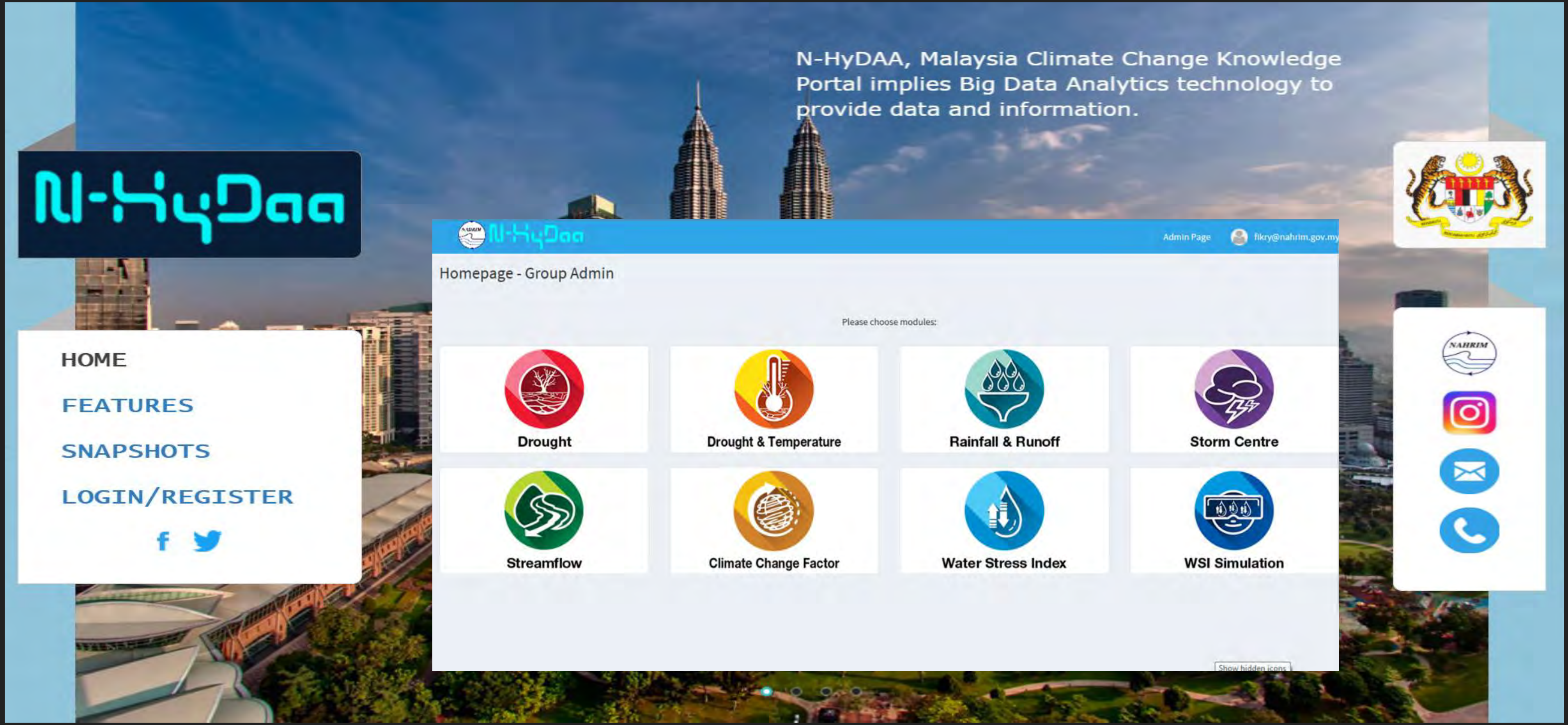
Downscaled CC data provides significant opportunity to re-evaluate the Malaysia's water and other sectors under the hydro-climate conditions of the next 90 years of the 21st century

THANK YOU

Pusat Kajian Sumber Air dan Perubahan Iklim,
Institut Penyelidikan Hidraulik Kebangsaan Malaysia (NAHRIM),
Lot 5377,
Jalan Putra Permai,
43300 Seri Kembangan,
Selangor Darul Ehsan.

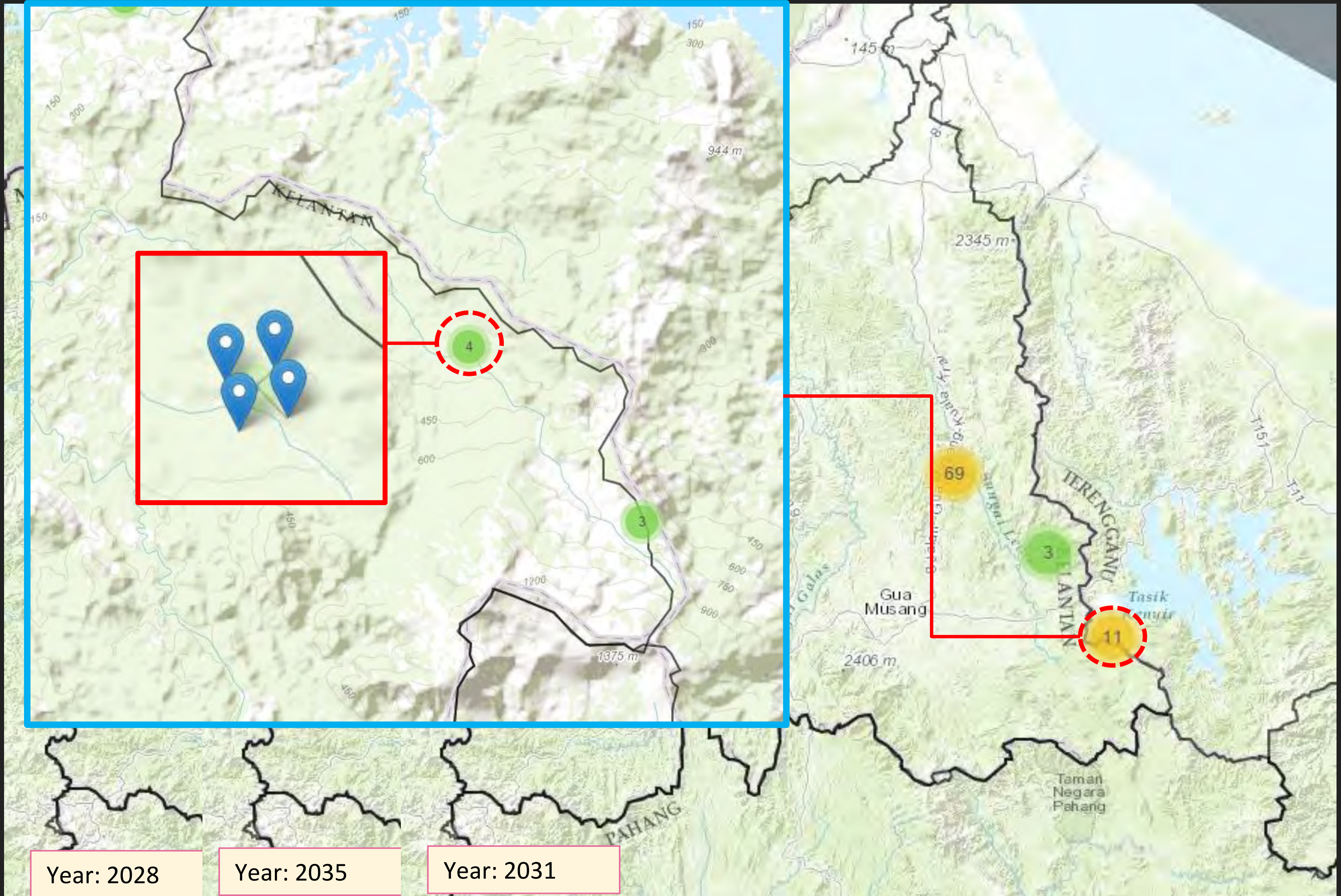
T : 603 8947 6400
F : 603 8948 3044
E :iphk@nahrim.gov.my

HYDRO-CLIMATE DATA ANALYSIS ACCELERATOR

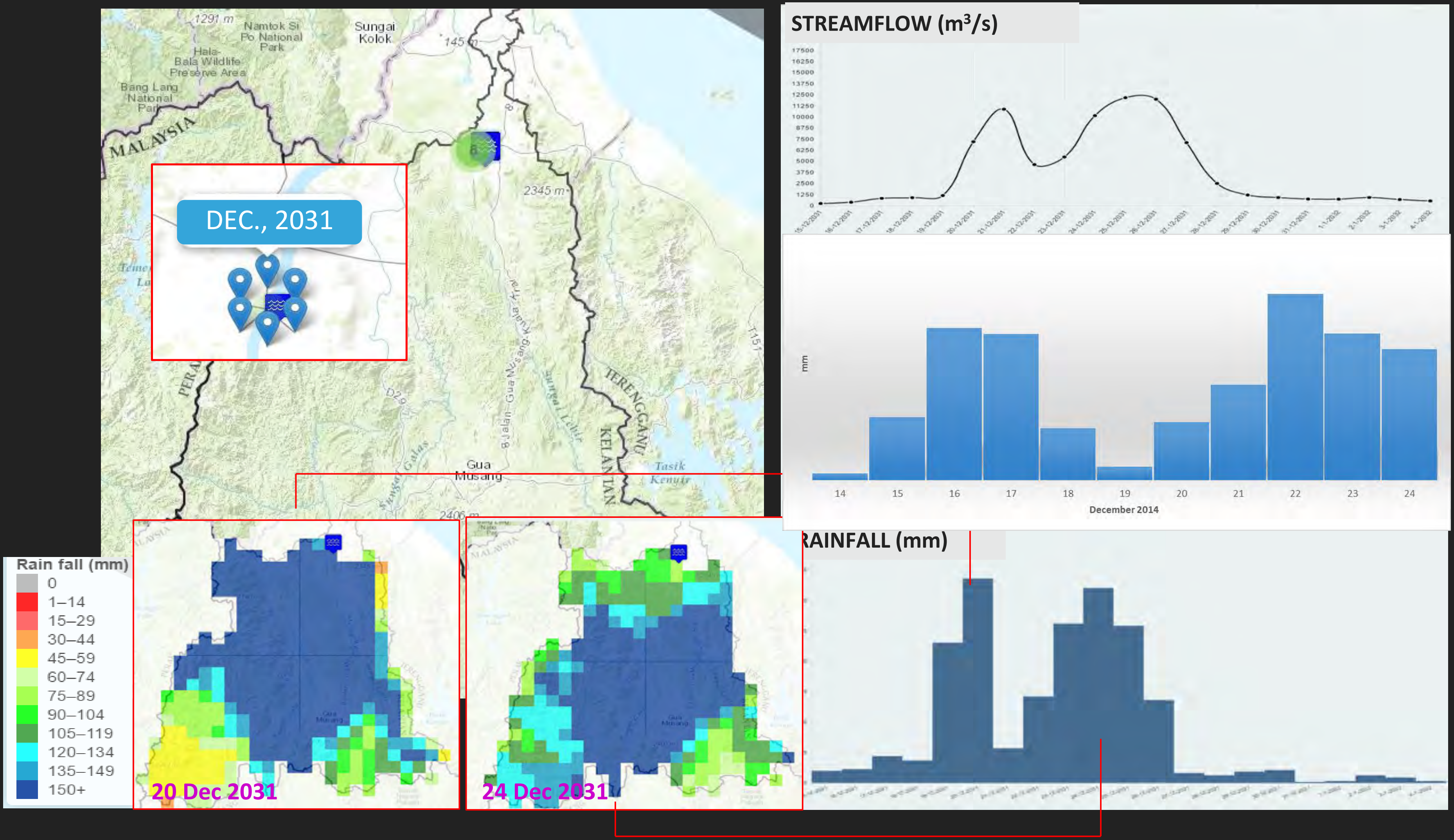


- Web-based application
- Consist of 8 Modules
- Big Data Analytics
- 1st Climate Change Knowledge Portal in Malaysia
- Analysis based on 10 Billions Hydro-climate Data
- Improved Decision Making

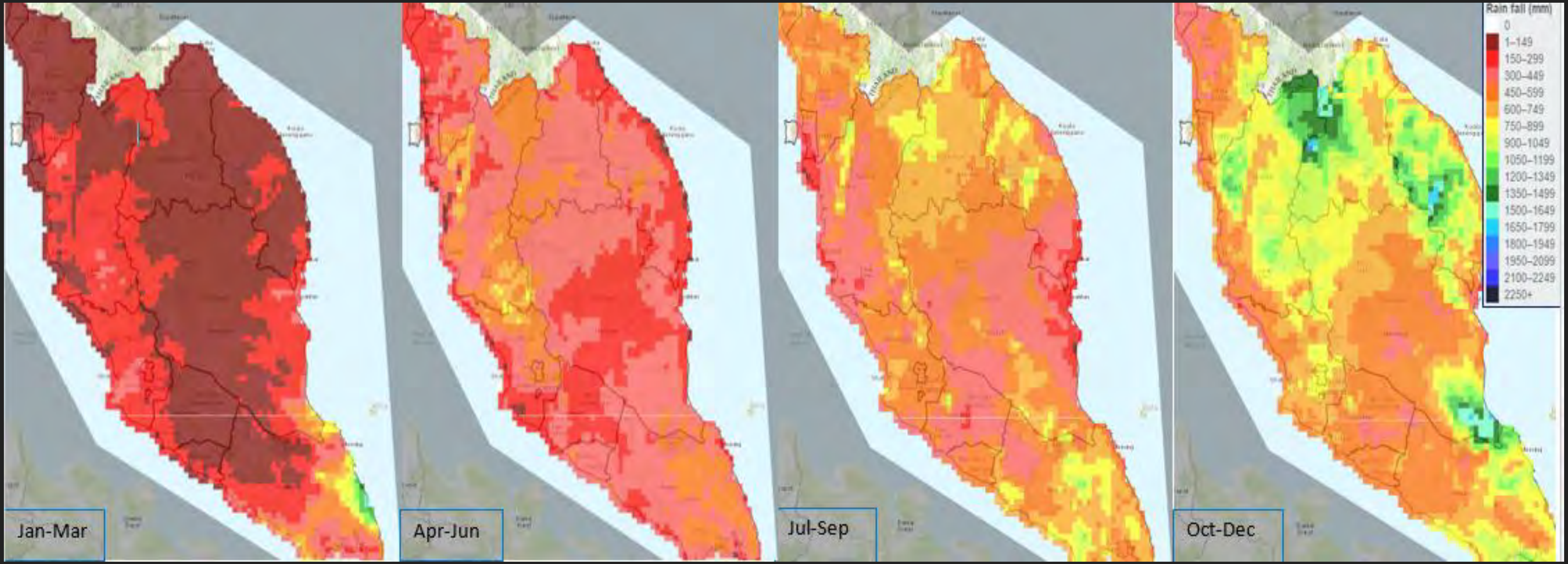
MODULE	FEATURES	ISSUES	IMPACTS | ACTIONS
STORMCENTRE	uncover hidden pattern of stormcentre	• Expanded flood hazard areas, • Inland Flood • Coastal Flood	• Water Facilities/Utilities • Transportation • Telecommunication • Energy utilities



MODULE	FEATURES	ISSUES	IMPACT
STREAMFLOW	• uncover hidden pattern • trend, pattern and magnitude	• Expanded flood hazard areas, • Inland Flood • Coastal Flood	• Water Facilities/Utilities • Transportation • Telecommunication • Energy utilities

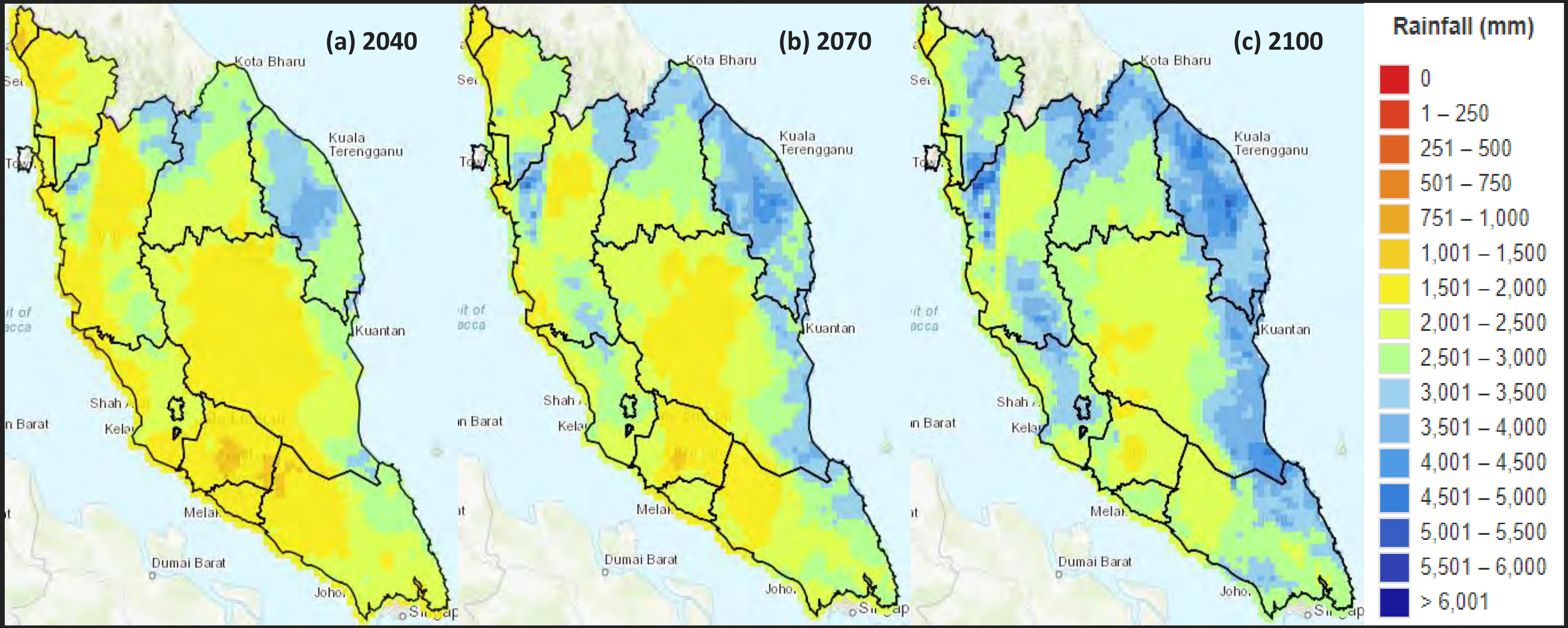


MODULE	FEATURES	ISSUES	IMPACTS | ACTIONS
DROUGHT	• Location, magnitude and pattern	• Prolonged dry periods	• Threats to future water resources and supply



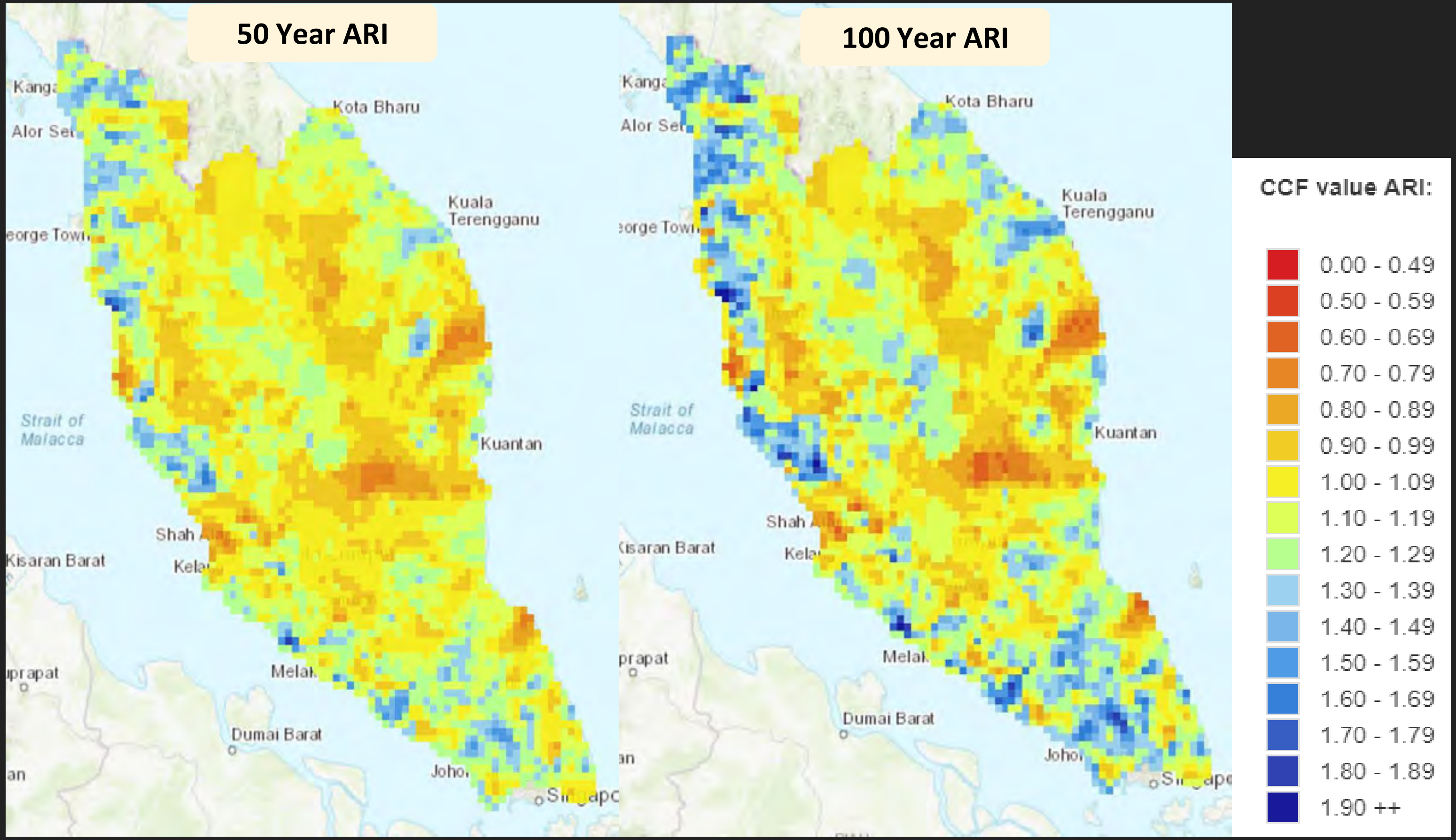
CHANGES IN PROJECTED THREE-MONTH RAINFALL (IN MM) IN TIME HORIZON 2020-2030
(WEEKLY | MONTHLY | 3-MONTHLY | 6-MONTLY)

MODULE	FEATURES	ISSUES	IMPACTS | ACTIONS
RAINFALL	• Trend, pattern and magnitude	• Water supply • Water resources • River flow • River pollution	• Increase risk management cost, • Loss of lives, infrastructures &, properties • Environmental degradation



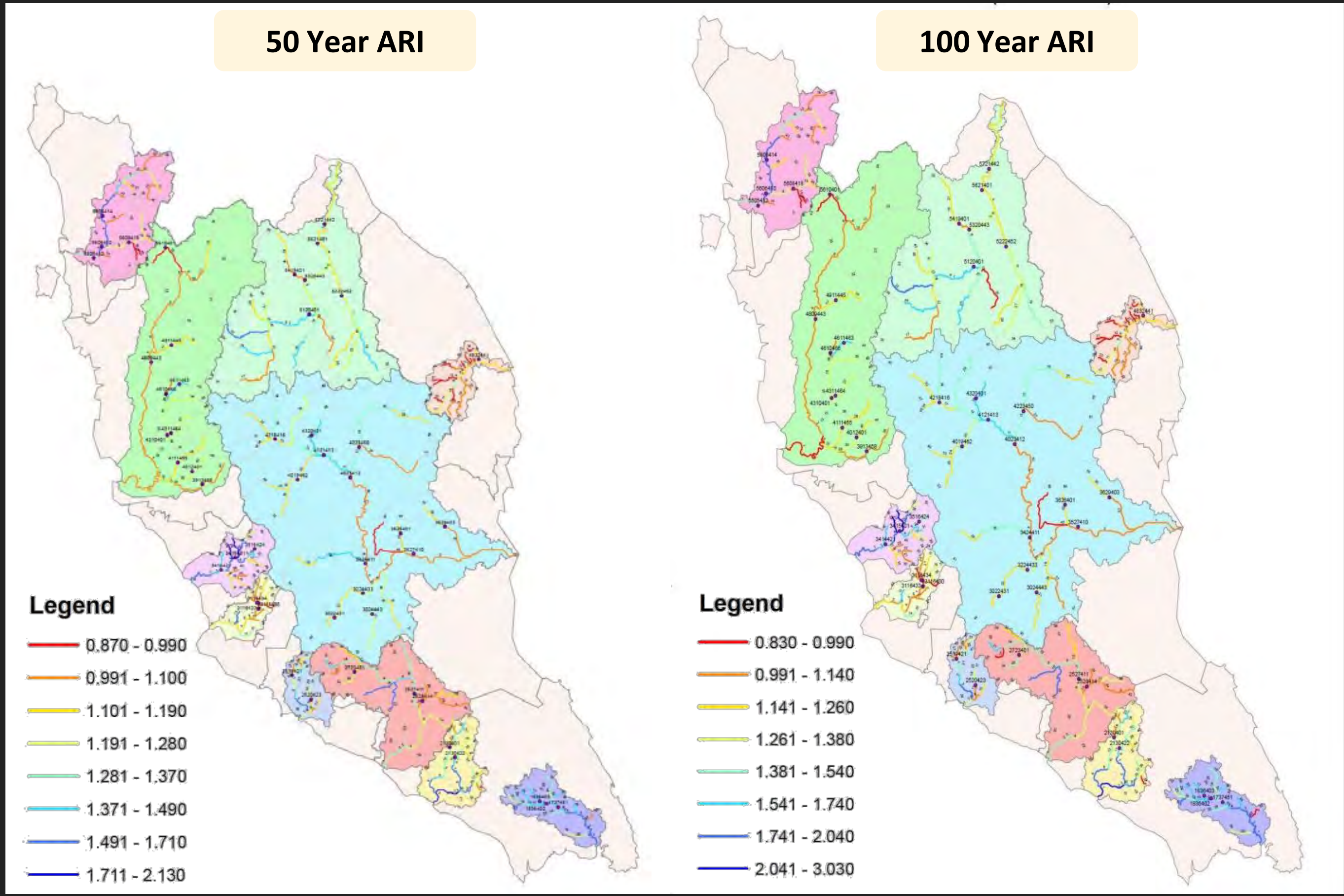
MODULE	FEATURES	ISSUES	IMPACTS | ACTIONS
CLIMATE CHANGE FACTOR	• **Increase/decrease of rainfall intensity/magnitude** • Increase/decrease of flood magnitude & low flow magnitude	• Integrity of water related infrastructure	• Improve design guide, engineering practices and building codes

1. CCF DESIGN RAINSTORM



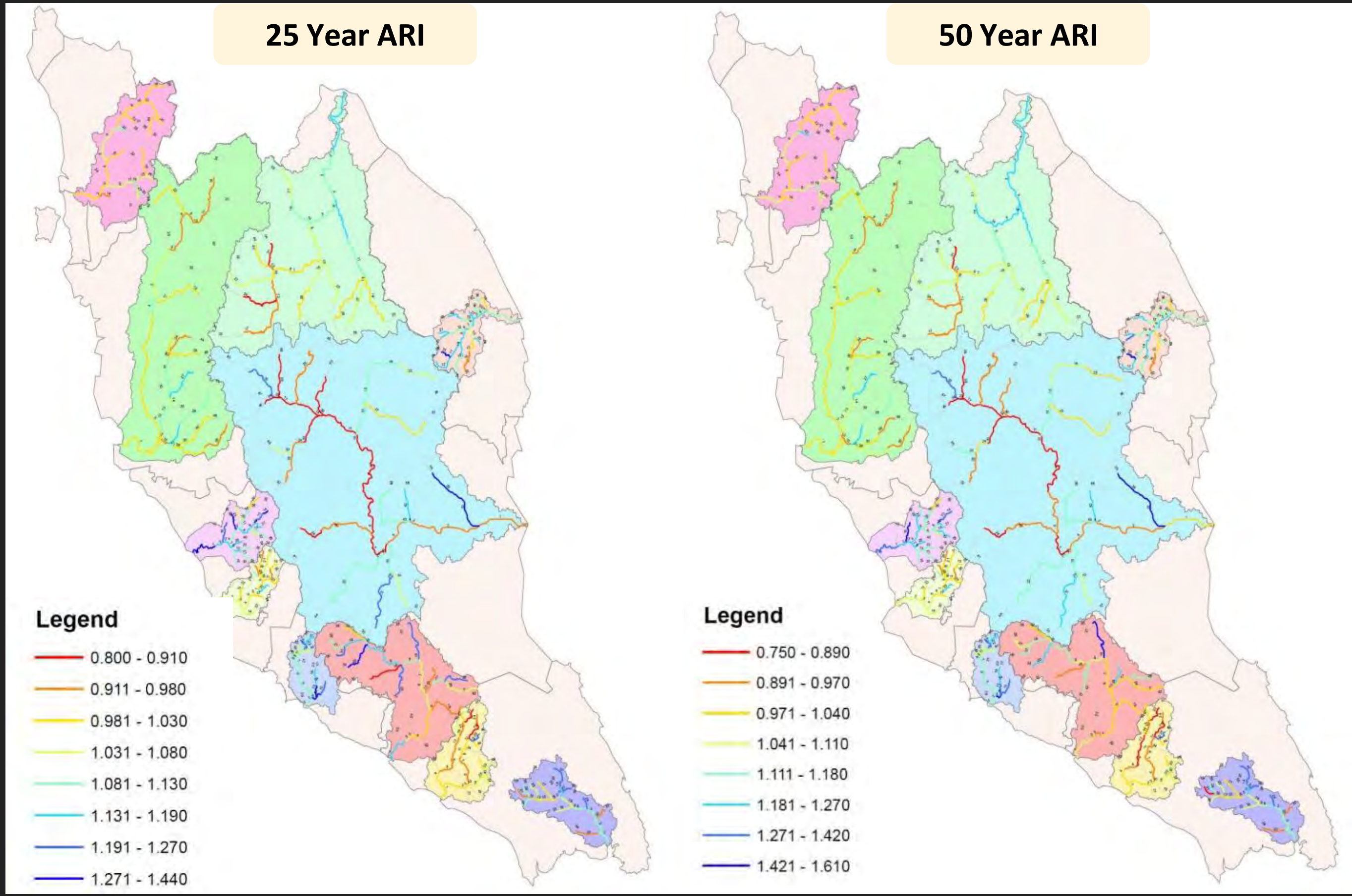
MODULE	FEATURES	ISSUES	IMPACTS | ACTIONS
CLIMATE CHANGE FACTOR	• Increase/decrease of rainfall intensity/magnitude • Increase/decrease of **flood magnitude** & low flow magnitude	• Integrity of water related infrastructure	• Improve design guide, engineering practices and building codes

2. CCF DESIGN FLOOD

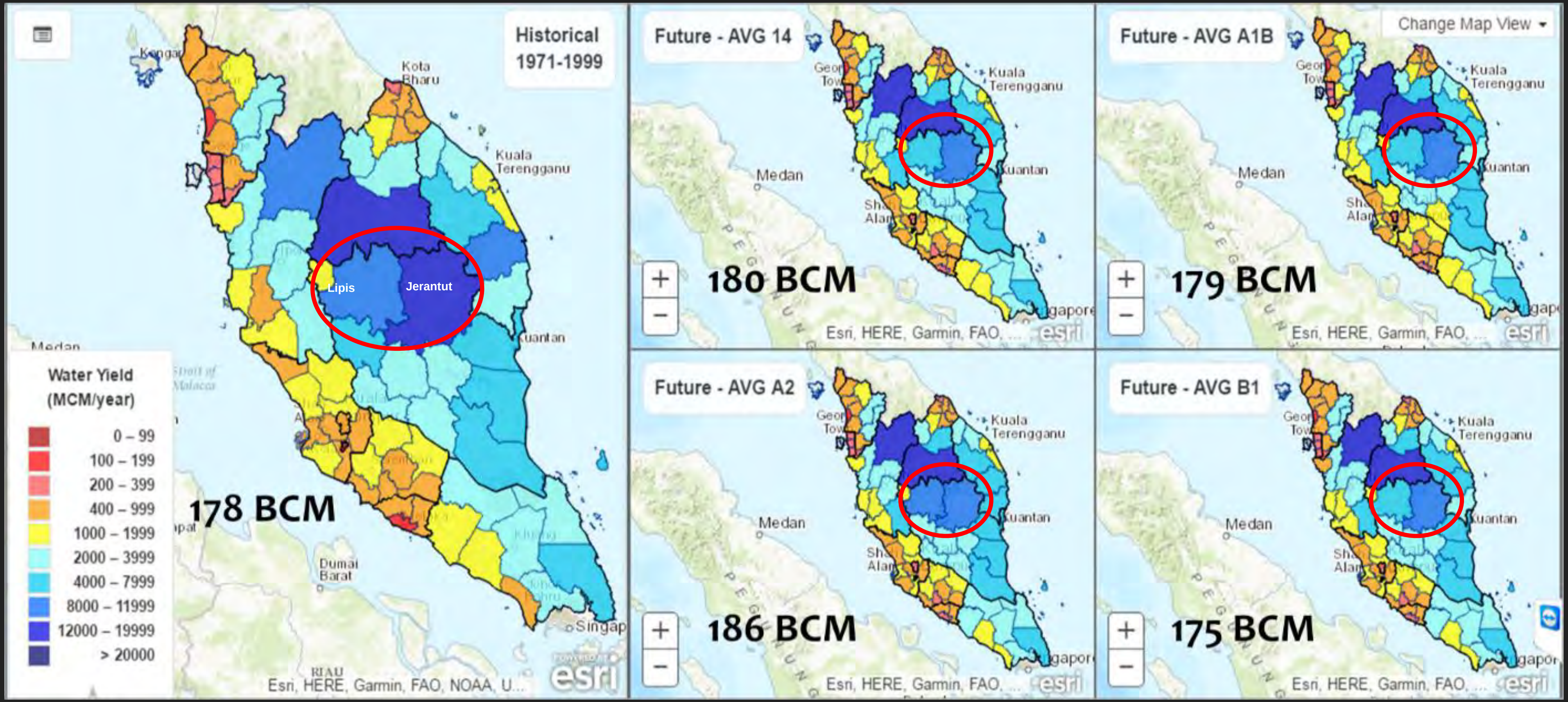


MODULE	FEATURES	ISSUES	IMPACTS | ACTIONS
CLIMATE CHANGE FACTOR	• Increase/decrease of rainfall intensity/magnitude • Flood magnitude & **low flow magnitude**	• Integrity of water related infrastructure	• Improve design guide, engineering practices and building codes

3. CCF DESIGN LOW FLOW

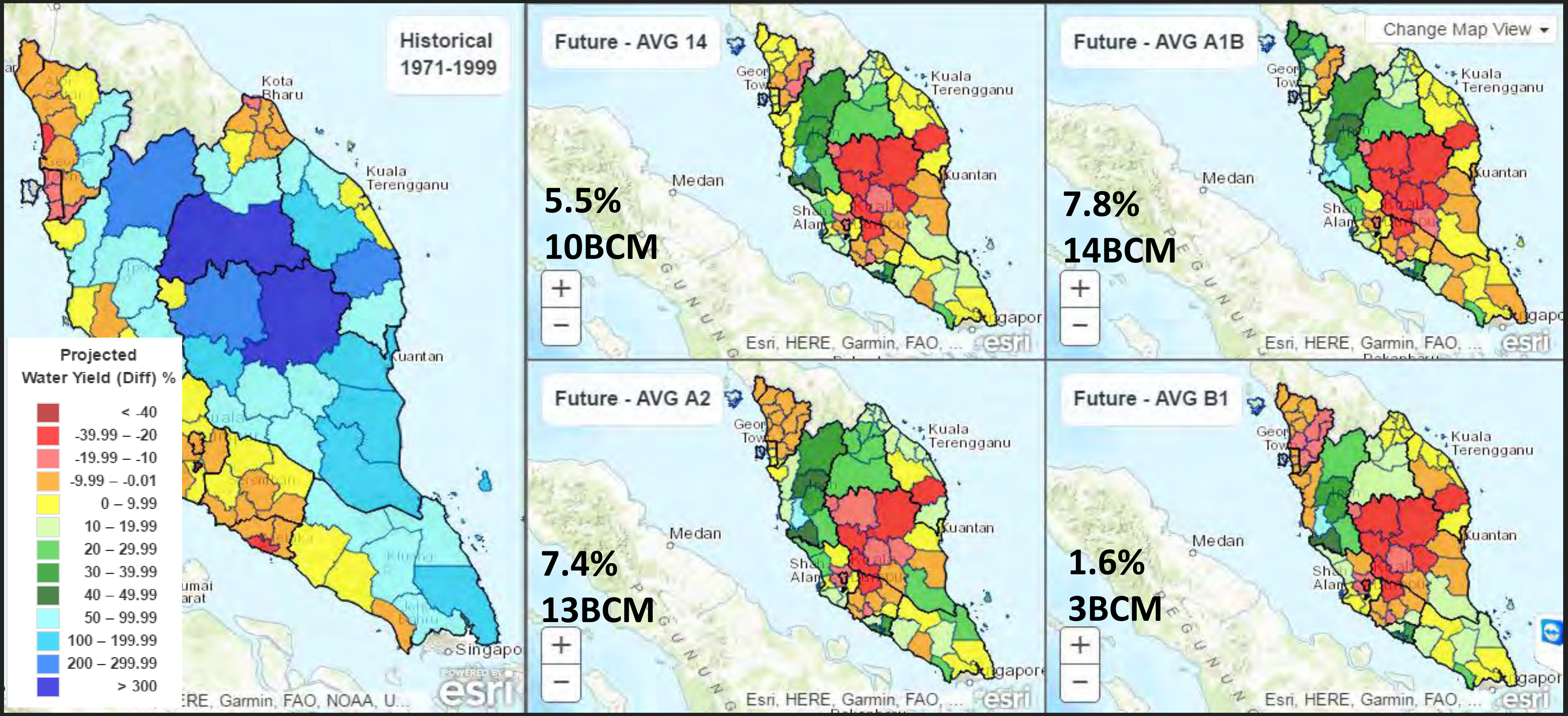


MODULE	FEATURES	ISSUES	IMPACT
WATER STRESS INDEX (WSI) & WSI SIMULATION	• Water Stress Index • Water Surplus-Defisit • **Water Yield** • Water Yield Different • Water Demand • Water Provision	• Water Supply • Water Treatment Plant • Reservoir capacity • Hydro electric generation	• Water Management • Water Planning • Water conservation • Water consumption



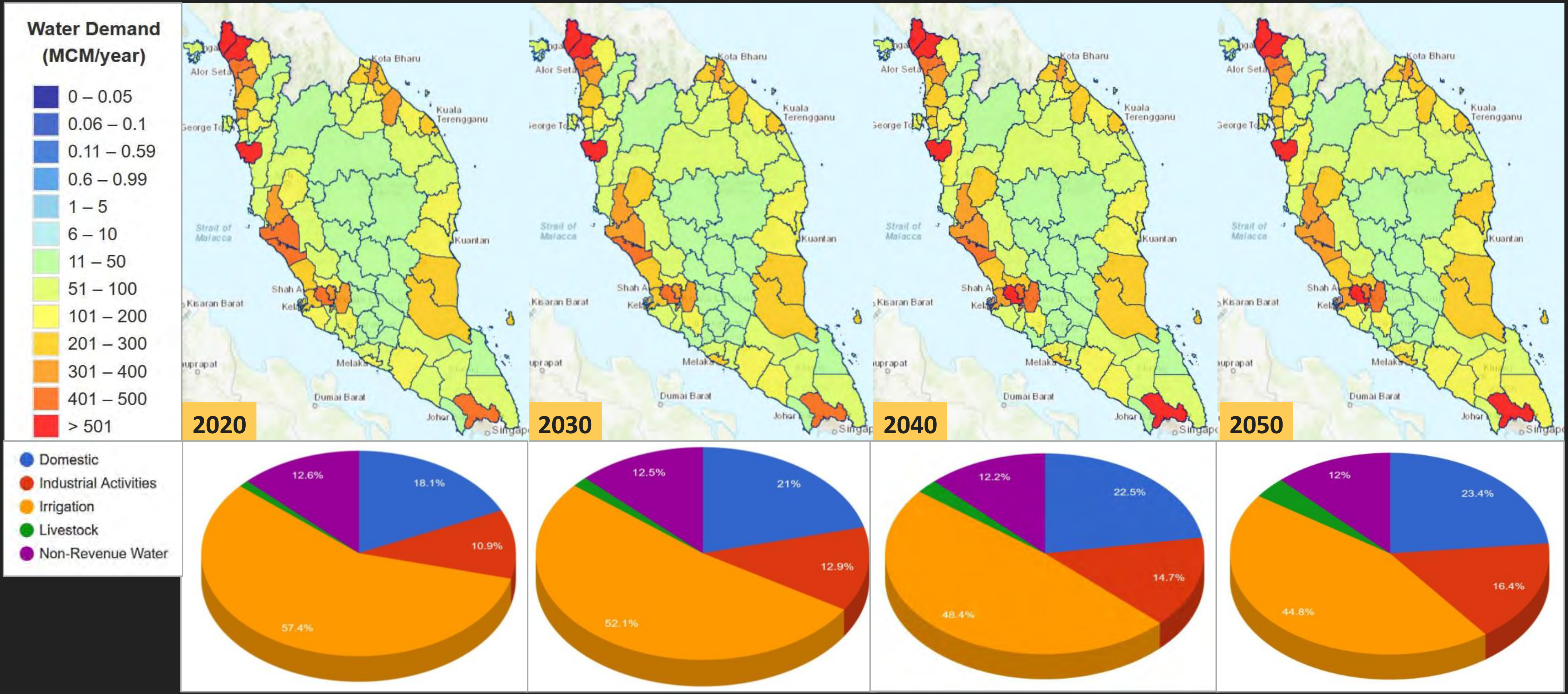
Projected Water Yield - 2030

MODULE	FEATURES	ISSUES	IMPACT
WATER STRESS INDEX (WSI) & WSI SIMULATION	• Water Stress Index • Water Surplus-Defisit • Water Yield • **Water Yield Different** • Water Demand • Water Provision	• Water Supply • Water Treatment Plant • Reservoir capacity • Hydro electric generation	• Water Management • Water Planning • Water conservation • Water consumption

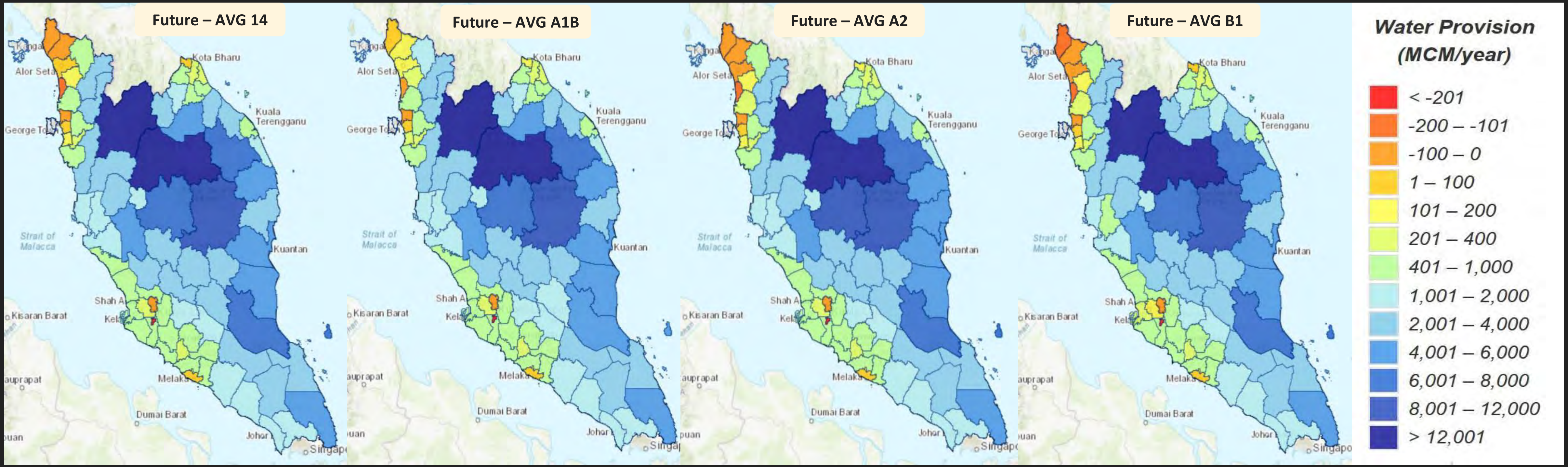


Projected Water Yield Different - 2030

MODULE	FEATURES	ISSUES	IMPACTS | ACTIONS
WATER STRESS INDEX (WSI) & WSI SIMULATION	• Water Stress Index • Water Surplus-Defisit • Water Yield • Water Yield Different • **Water Demand** • Water Provision	• Water Supply • Water Treatment Plant • Reservoir capacity • Hydro electric generation	• Water Management • Water Planning • Water conservation • Water consumption

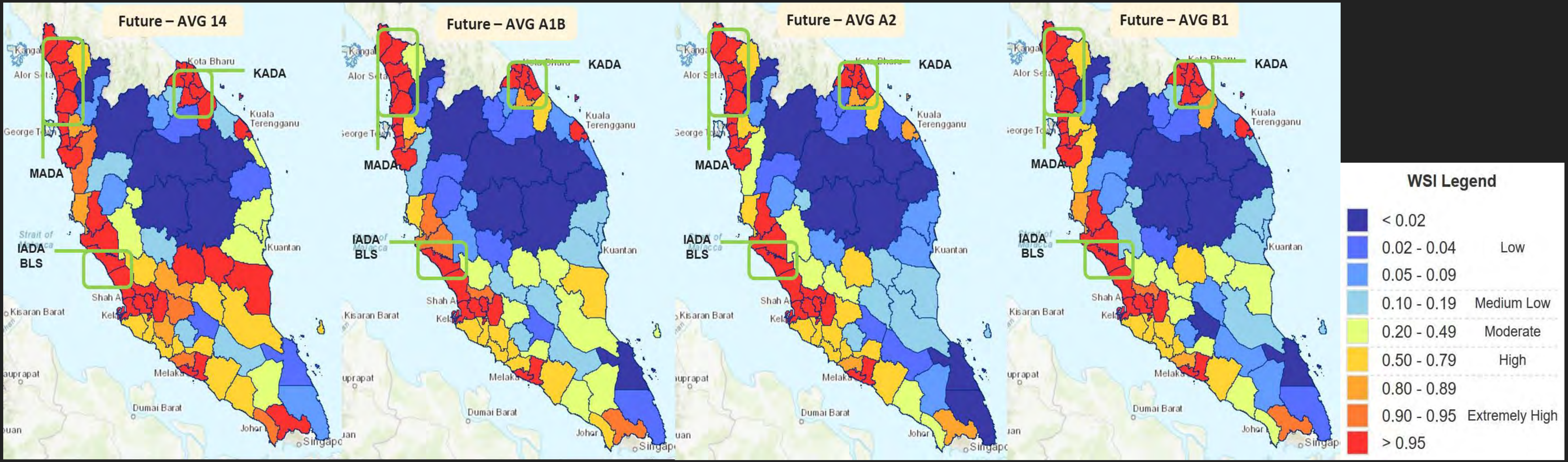


MODULE	FEATURES	ISSUES	IMPACTS | ACTIONS
WATER STRESS INDEX (WSI) & WSI SIMULATION	• Water Stress Index • **Water Surplus-Defisit** • Water Yield • Water Yield Different • Water Demand • Water Provision	• Water Supply • Water Treatment Plant • Reservoir capacity • Hydro electric generation	• Water Management • Water Planning • Water conservation • Water consumption



Projected Water Surplus-Deficit - 2030

MODULE	FEATURES	ISSUES	IMPACTS | ACTIONS
WATER STRESS INDEX (WSI) & WSI SIMULATION	• Water Stress Index • Water Surplus-Defisit • Water Yield • Water Yield Different • Water Demand • Water Provision	• Water Supply • Water Treatment Plant • Reservoir capacity • Hydro electric generation	• Water Management • Water Planning • Water conservation • Water consumption



Projected Water Stress Index - 2030

THANK YOU

Pusat Kajian Sumber Air dan
Perubahan Iklim,
Institut Penyelidikan Hidraulik
Kebangsaan Malaysia (NAHRIM),
Lot 5377,
Jalan Putra Permai,
43300 Seri Kembangan,
Selangor Darul Ehsan.

T : 603 8947 6400
F : 603 8948 3044
E :iphk@nahrim.gov.my