Seminar on Climate Change and Health: Exploring the Linkages
UNU-IIGH, UKM Medical Centre, 4 May 2017

UNITED NATIONS UNIVERSITY

HYDROLOGICAL CLIMATE –
IMPACT PROJECIONS IN MALAYSIA

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Presentation Outline

- **OVERVIEW ON CLIMATE CHANGE & HEALTH**
- **CLIMATE CHANGE PROJECTIONS**
- **PROJECTED CLIMATE CHANGE IMPACTS**
- **SUMMARY & WAY FORWARD**

OVERVIEW

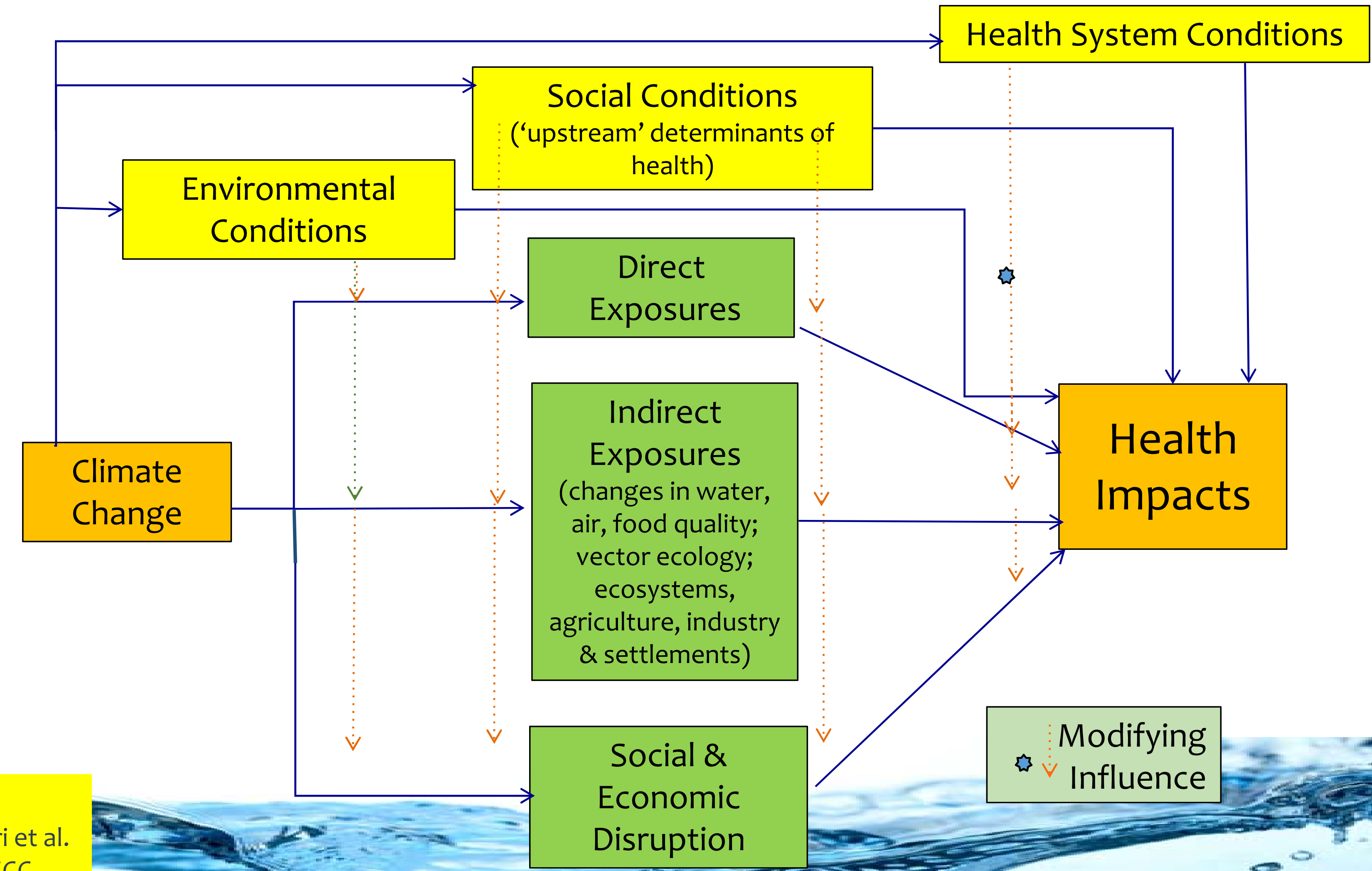
Climate Change & Health

Worldwide considerations on the potential health impacts from GCC

3 kinds	Relatively direct impacts from weather extremes
	Consequences of environmental change and ecological disruption
	Consequences that occur when populations are affected by CC induced factors

Source: WHO. 2003. Climate change and human health: risks and responses.

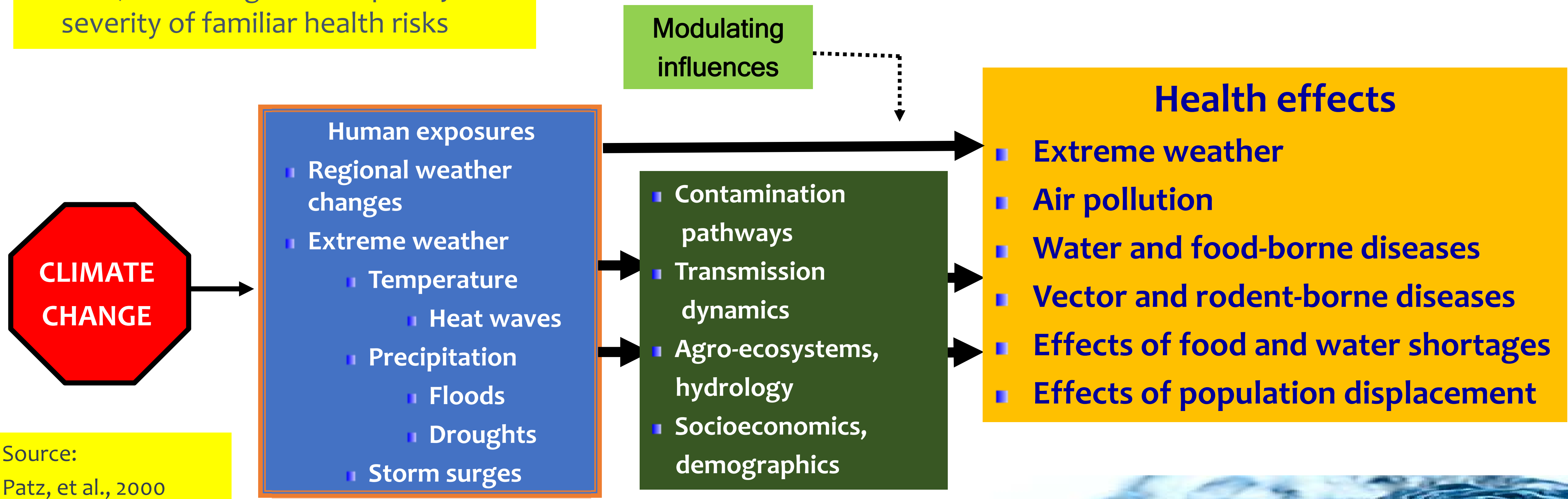
Pathways for Weather-Climate Changes that Impact Health



Source:
Confalonieri et al. 2007, UNFCCC

Mapping Links Between CC and Health

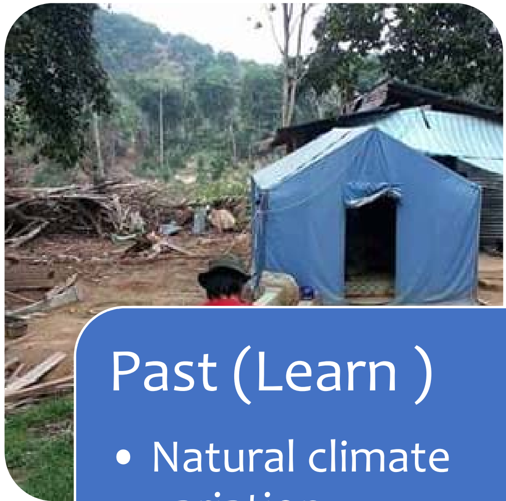
- Most expected impacts will be adverse but some will be beneficial.
- Expectations are not for new health risks, but changes in frequency and severity of familiar health risks



Source:
Patz, et al., 2000

CLIMATE CHANGE PROJECTIONS

CC – Downscale and Assessment

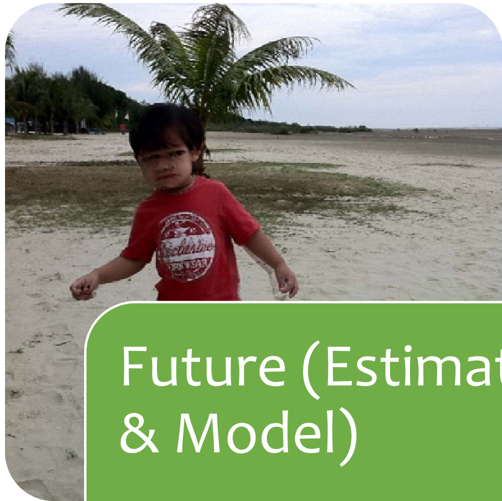


Past (Learn)

- Natural climate variation
- Identify effects and quantify risks

Present (Detect)

- Current CC
- Detect and quantify effects and attribute burdens

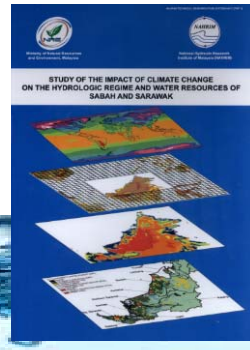


Future (Estimate & Model)

- Future CC
- Estimate risks and attribute burdens

Main CC Studies and Reports

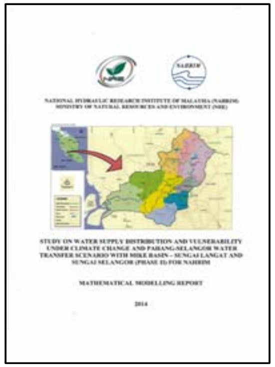
1. Study of the Impact of CC on the Hydrologic Regime & WR of Pen. M'sia (2006)
2. Climate Projection Downscaling for M'sia Using Hadley Centre PRECIS Model (2010)
3. Study of the Impact of CC on SLR in M'sia (2010);
4. Study of the Impact of CC on Hydrologic Regime & WR of Sabah and Sarawak (2010)
5. Extension Study of the Impact of CC on the Hydrologic Regime and WR of Pen. M'sia (2014)
6. Extension Study of the Impact of CC on the Hydrologic Regime – WR & SLR of Malaysia (Phase 2) – IPCC AR5/CMIP5 (2016-2019)



Main CC Studies and Reports

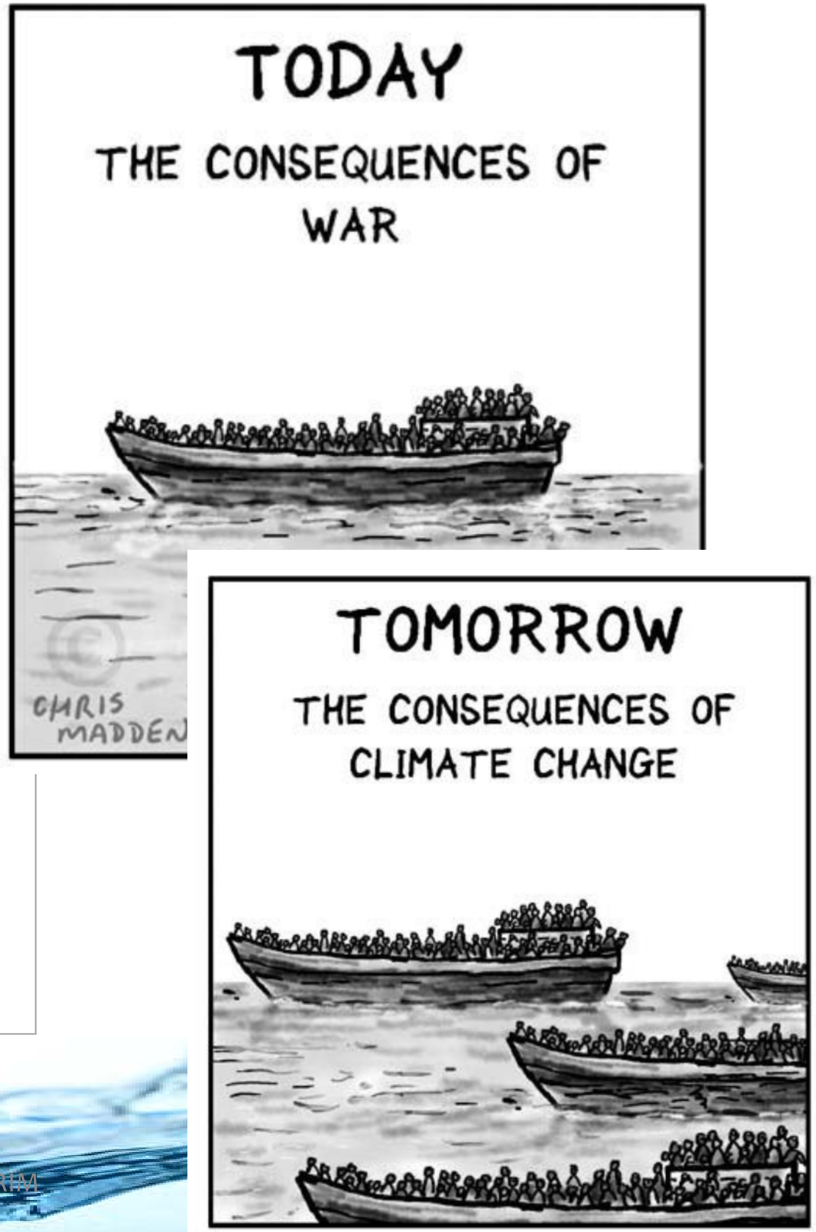
Downstream CC Studies: Impact, Vulnerability & Adaptation Assessments

1. Study of the Impact of CC on Hydrologic and Hydraulic Systems of Labong & Bekok Dams, Johor (2010)
2. Economics of CC for M'sia – WR Sector (2012)
3. NAHRIM Technical Guide No.1 – Estimation of Future Design Rainstorm under CC Scenario in Pen. M'sia (2013)
4. Study on Water Supply Distribution and Vulnerability under CC and Pahang-Selangor Inter-State Raw Water Transfer Scenarios with Mike Basin – Sg. Langat and Sg. Selangor (Phase II) (2014)
5. Study on Vulnerability and Adaptation of CC Impacts on Floods in Selected River Basins (2014)
6. Impact of CC on WR for Selected Plantation Areas in M'sia for Paddy, Rubber and Oil Palm (2014)
7. Study on Vulnerability, Adaptation and Assessment for WR & Dam Storage Capacities under CC Impacts Scenarios (2014)



Major Aspects Of CC

- Temperature, rainfall and sea level
- Extreme Events
  - more frequent very hot days;
  - more frequent and longer droughts;
  - more frequent and larger floods;
  - more frequent and more intense heavy rain;
  - more intense tropical cyclones;
  - more intense storms on-shore and off-shore;
  - higher peak wind speeds; and
  - higher storm surges



Major Aspects Of CC

CC Parameters	Impacts & Vulnerability
Temperature Rise	▪ Agriculture yield & crop productivity ▪ Montane environment ▪ Heat transfer in cooling facilities ▪ Transportation efficiency ▪ Vector capacities & transmission of diseases ▪ Energy requirements ▪ Peat/bush fires & haze
SLR	▪ Coastal flooding ▪ Agriculture & aquaculture socio-economic losses ▪ Saline intrusion ▪ Aquatic life

CC Parameters	Impacts & Vulnerability
Increase Rainfall Magnitude	▪ Floods ▪ Erosion ▪ Landslides ▪ Water contamination ▪ Diarrhoeal diseases ▪ Capacity of the vector diseases
Decrease Rainfall Magnitude	▪ Droughts ▪ Water supply ▪ Crop productivity ▪ Power generation ▪ Water contamination ▪ Diarrhoeal diseases ▪ Capacity of the vector diseases ▪ Peat/bush fires & haze ▪ Subsidence

Projected CC Impacts for Malaysia

Annual Surface Temperature

Peninsular Malaysia
[2050] 1.0 - 1.5°C
[2100] 2.52 - 2.95°C

Sarawak
[2050] 1.0 - 1.5°C
[2100] 3.0 - 3.3°C

Sabah
[2050] 1.3 - 1.7°C
[2100] 2.9 - 3.5°C

Maximum Monthly Rainfall

Peninsular Malaysia
[2050] +113mm(12%)

Sarawak
[2050] +150mm (8%)
[2100] +282mm (32%)

Sabah
[2050] +59mm (5.1%)
[2100] +111mm (9%)

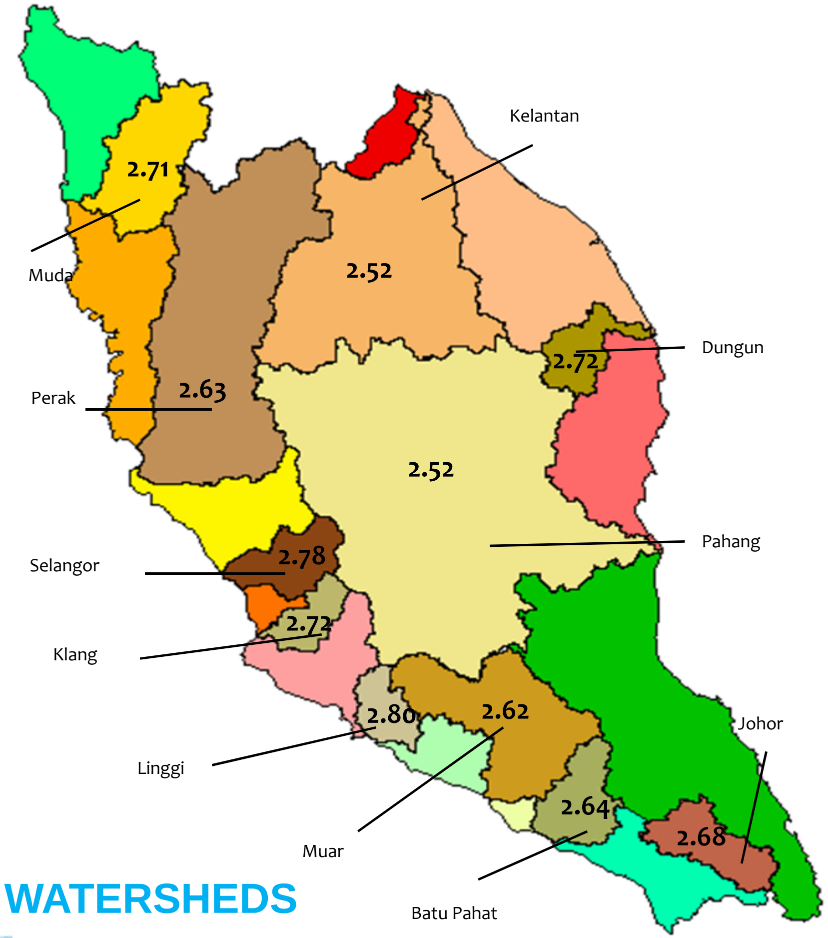
Sea Level Rise (2100)

Peninsular Malaysia
0.25 - 0.52m

Sarawak
0.43 - 0.63m

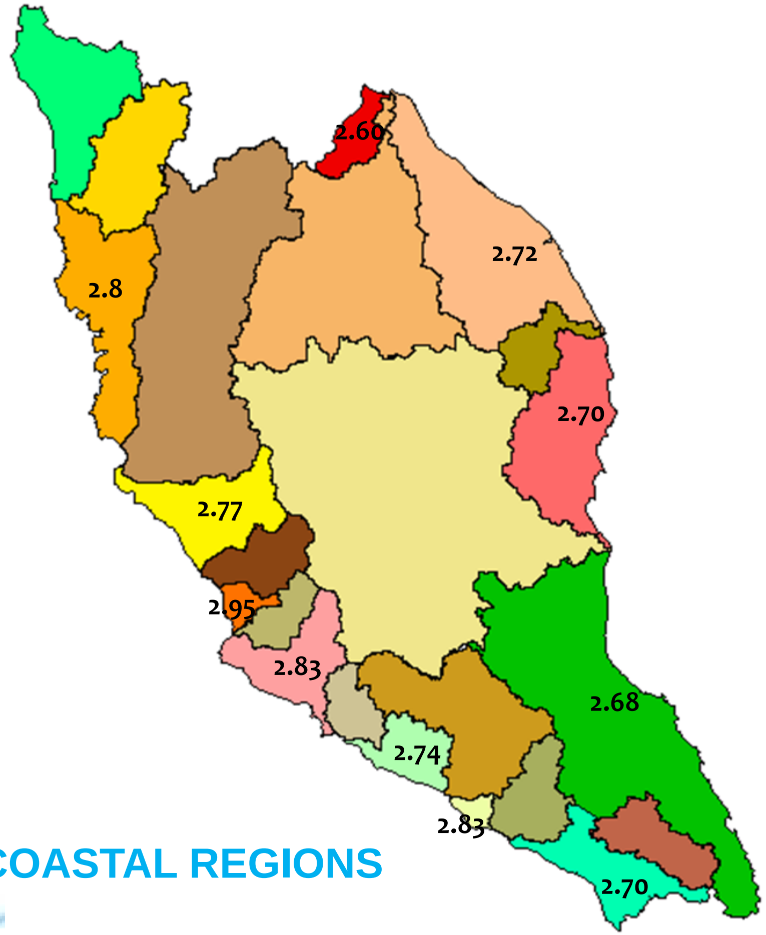
Sabah
0.64 - 1.03m

Projected Surface Temperature by 2100 – Peninsular Malaysia



11 WATERSHEDS

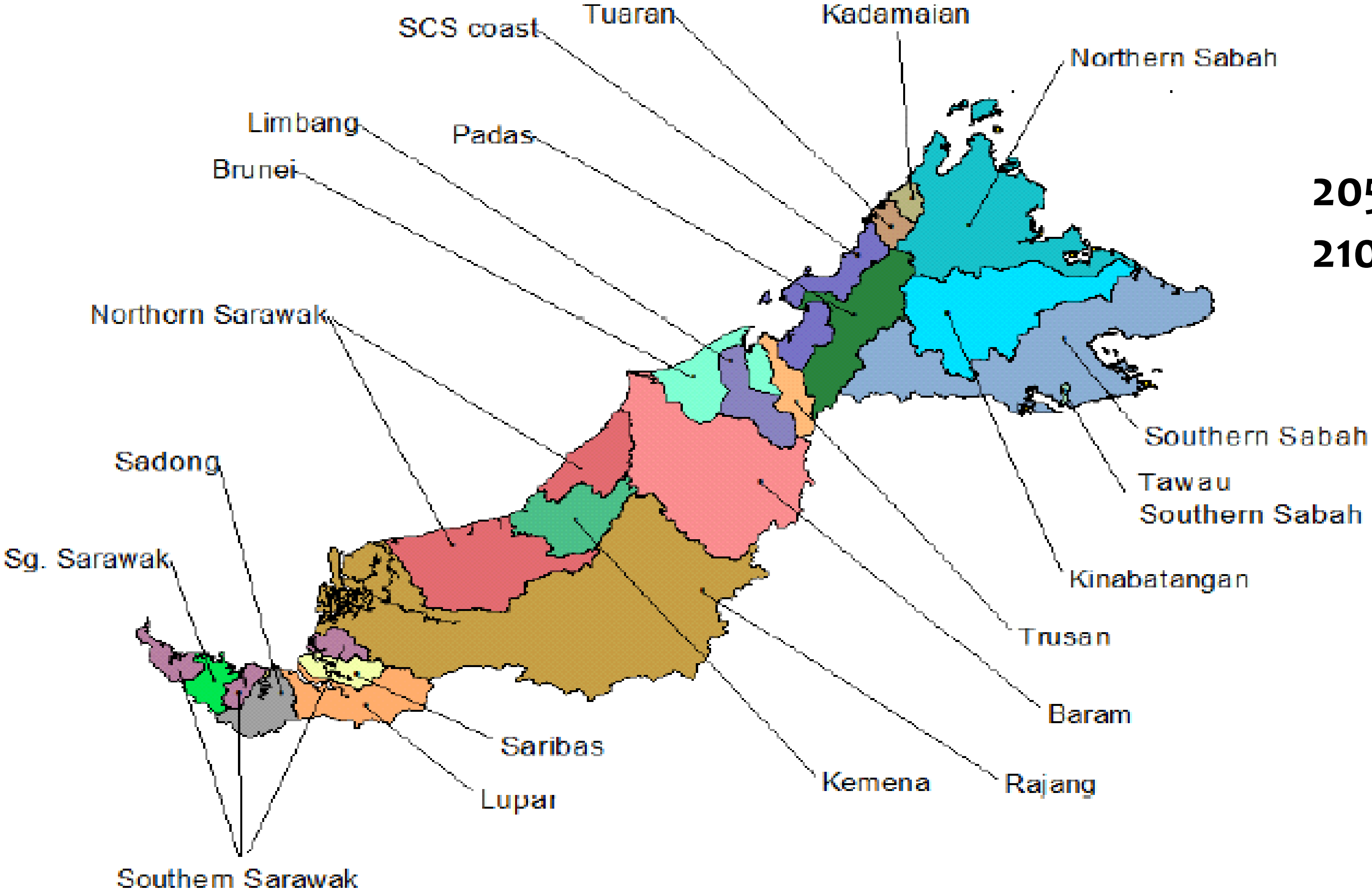
2050 0.94°C
2100 2.72°C



12 COASTAL REGIONS

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

30-year Mean Basin Average Surface Temperature for Sabah and Sarawak

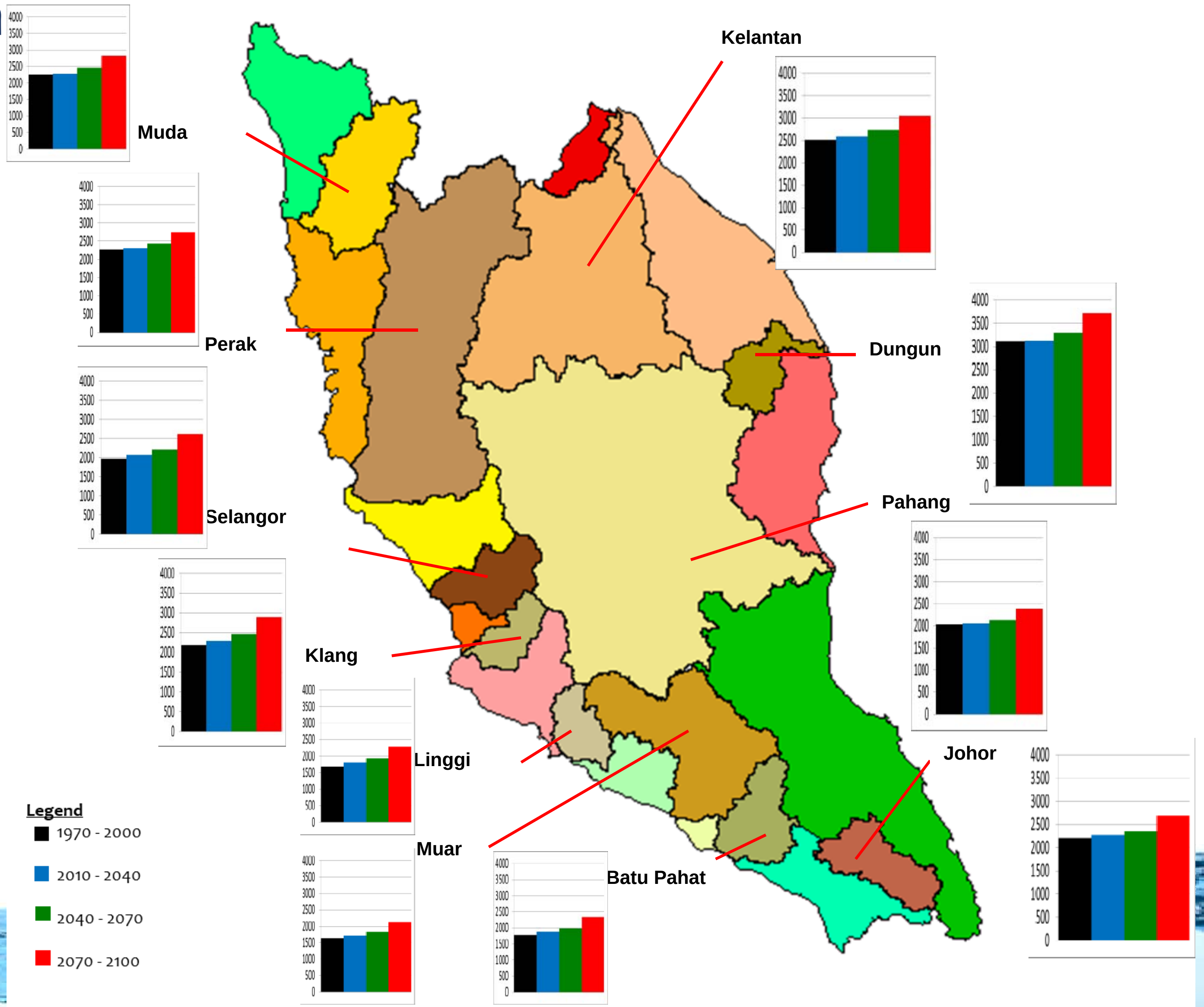


2050 1.51°C

2100 3.27°C

30-year Mean Basin Average Annual Precipitation

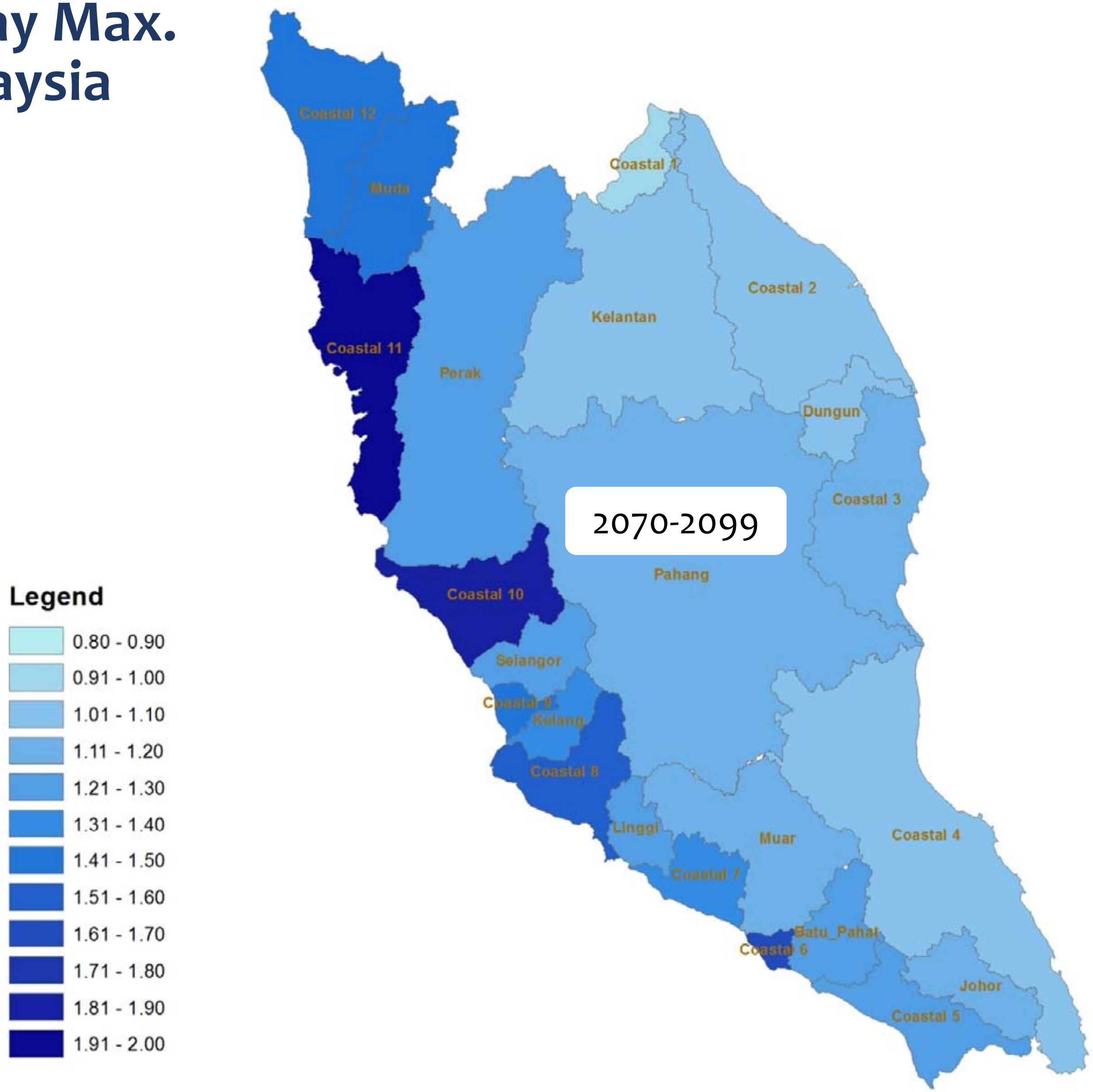
Magnitude of Change		
Period	30-yr Annual Precipitation	
	mm	%
2010-2040	12 - 121	0.4 - 6
2040-2070	96 - 278	5 - 13
2070-2100	348 - 714	17 - 33



30-year Basin Average 1-Day Max. Precipitation for Pen. Malaysia

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

Magnitude of Change (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



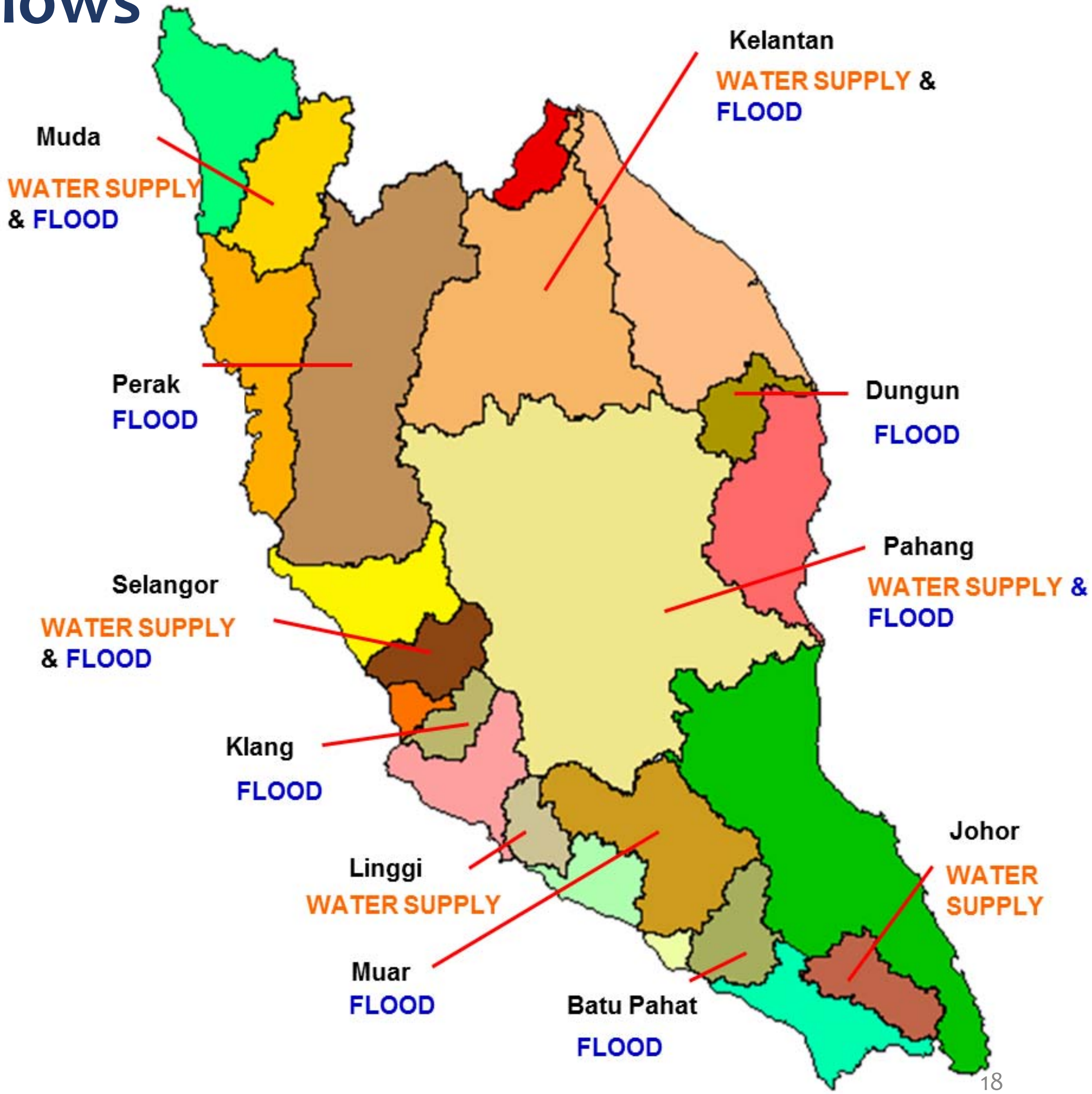
Projected High and Low Flows by 2100 for Pen. Malaysia

Low Flow (m³/s)

Watershed	2010-2100	1970-2000*	Change Rate
Muda	7.5	14.5	-48%
Selangor	117.7	122	-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 (m³/s)

Watershed	2010-2100	1970-2000*	Change Rate
Muda	2702.1	509.6	+430%
Perak	9936.9	2658.3	+274%
Selangor	1193.5	583.5	+108%
Klang	318.5	148.1	+115%
Kelantan	10114.7	4087.5	+147%
Dungun	671.3	414.9	+62%
Pahang	4561.2	2748.2	+66%
Muar	2630.2	401.2	+556%
Batu Pahat	283.2	101	+180%



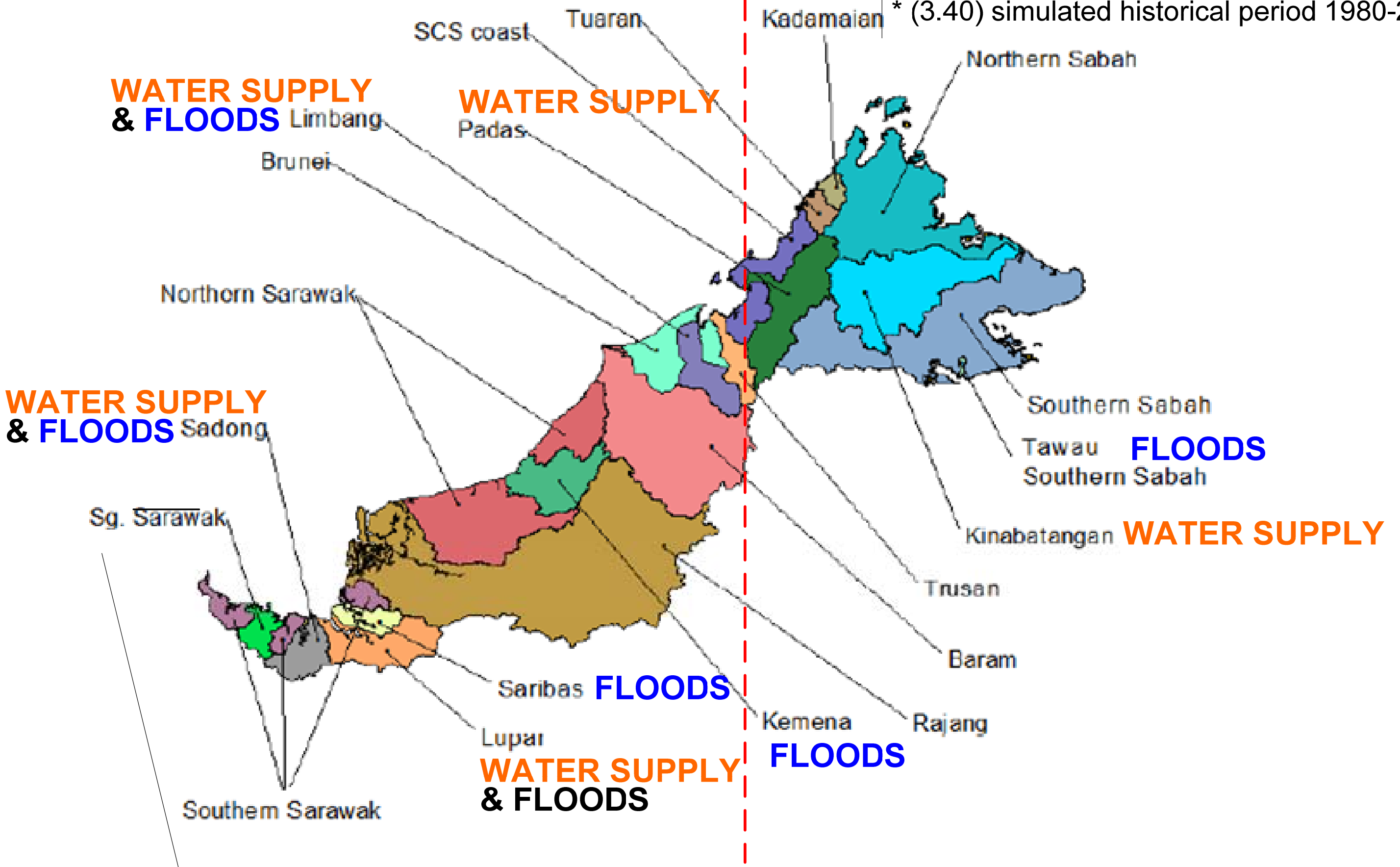
Projected High and Low Flows by 2100 – Sabah & Sarawak

- **Potential flooding problems** in Sabah (Tawau & Kedamaian river basins) and Sarawak (Sadong, Limbang, Kemena, Saribas, Lupar & Sarawak river basins); and
- **Potential water supply problems** in Sabah (Kinabatangan, Padas and Kadamaian river basins) and Sarawak (Sadong, Limbang & Lupar river basins).

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)

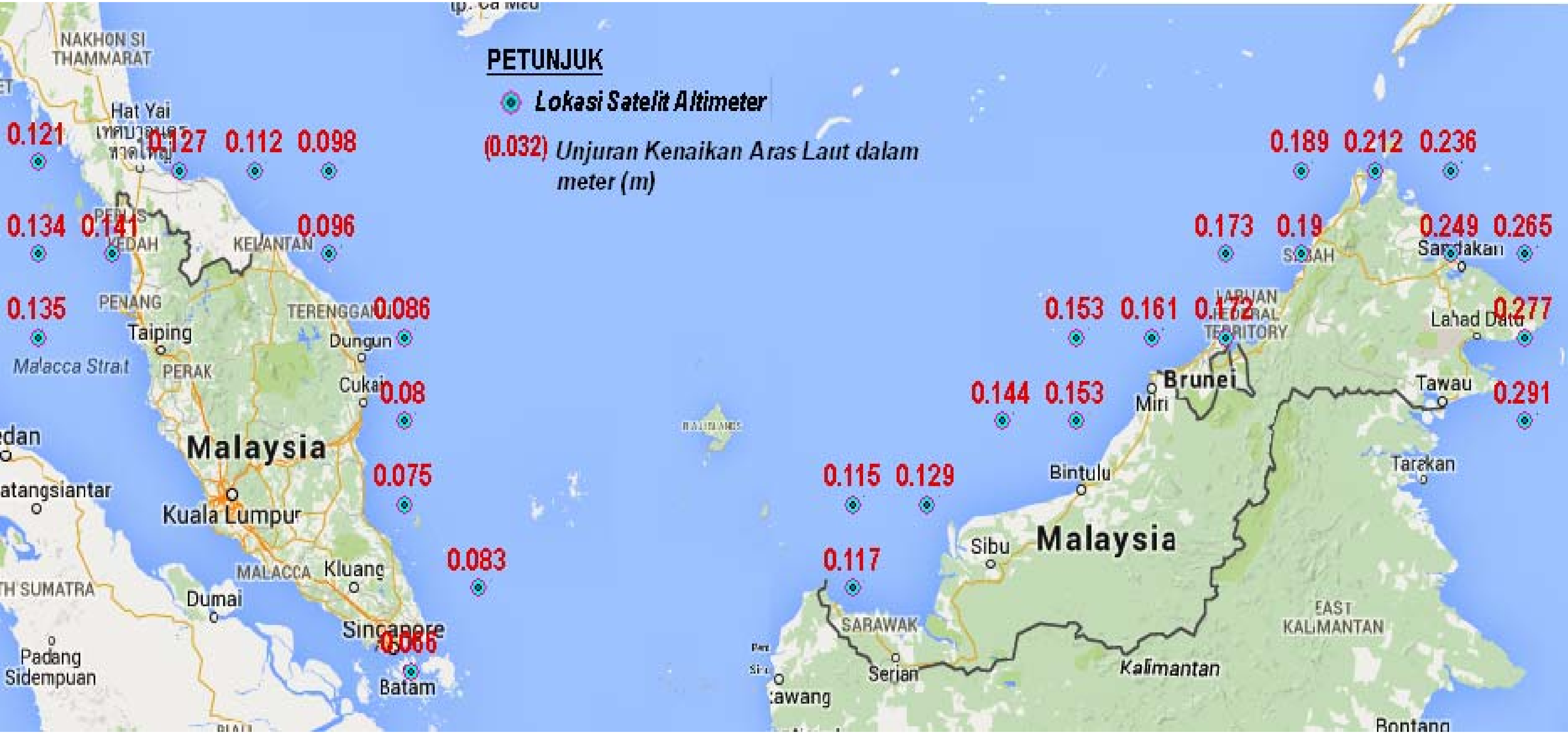
* (3.40) simulated historical period 1980-2000



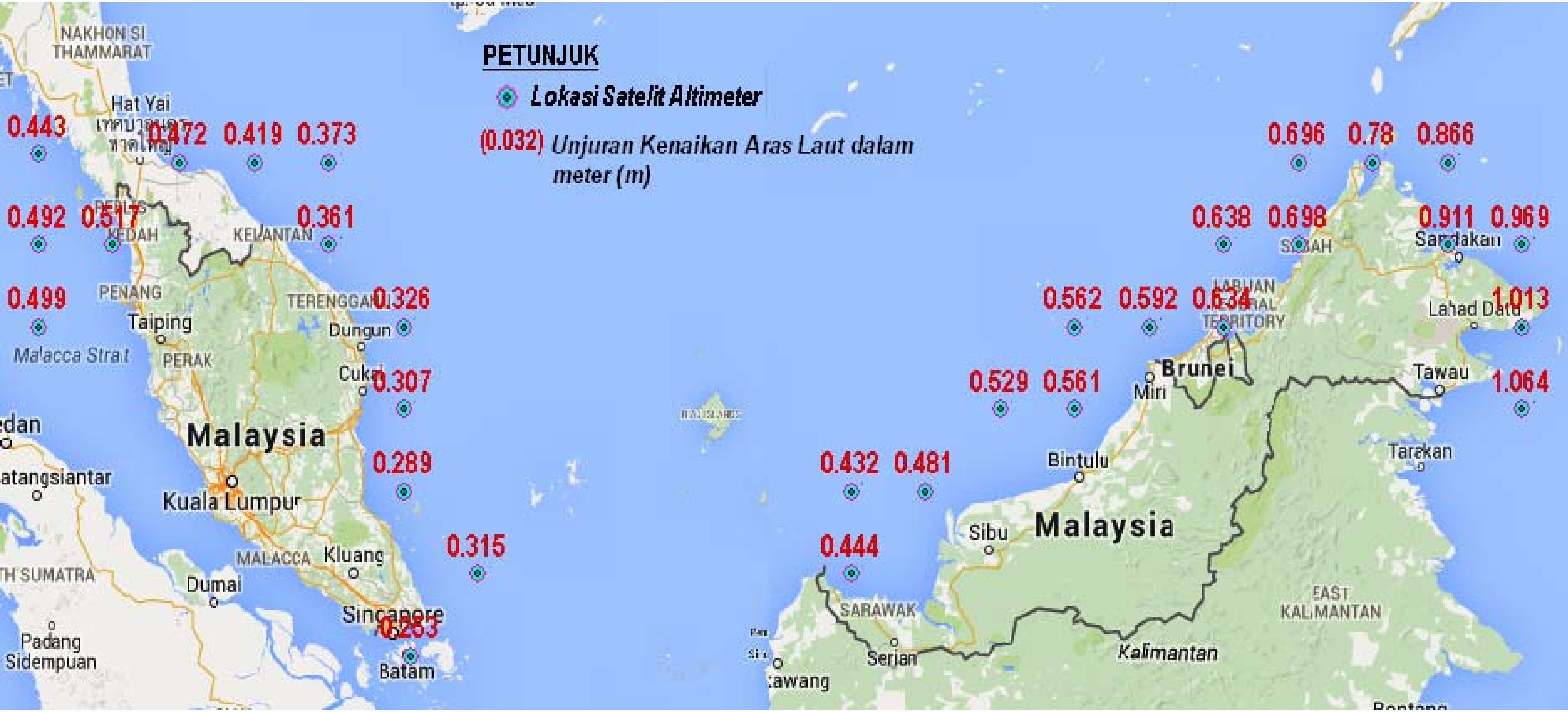
SARAWAK R. (FLOODS)

	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)

Mean SLR Projections (m) by 2040 (IPCC AR4)



Mean SLR Projections (m) by 2100 (IPCC AR4)



PROJECTED FLOODS

Kelantan Floods: Dec 2014 & Jan 2015

Continuous heavy downpour & upstream flooding..

Properties & infrastructures destroyed..

25 deaths..

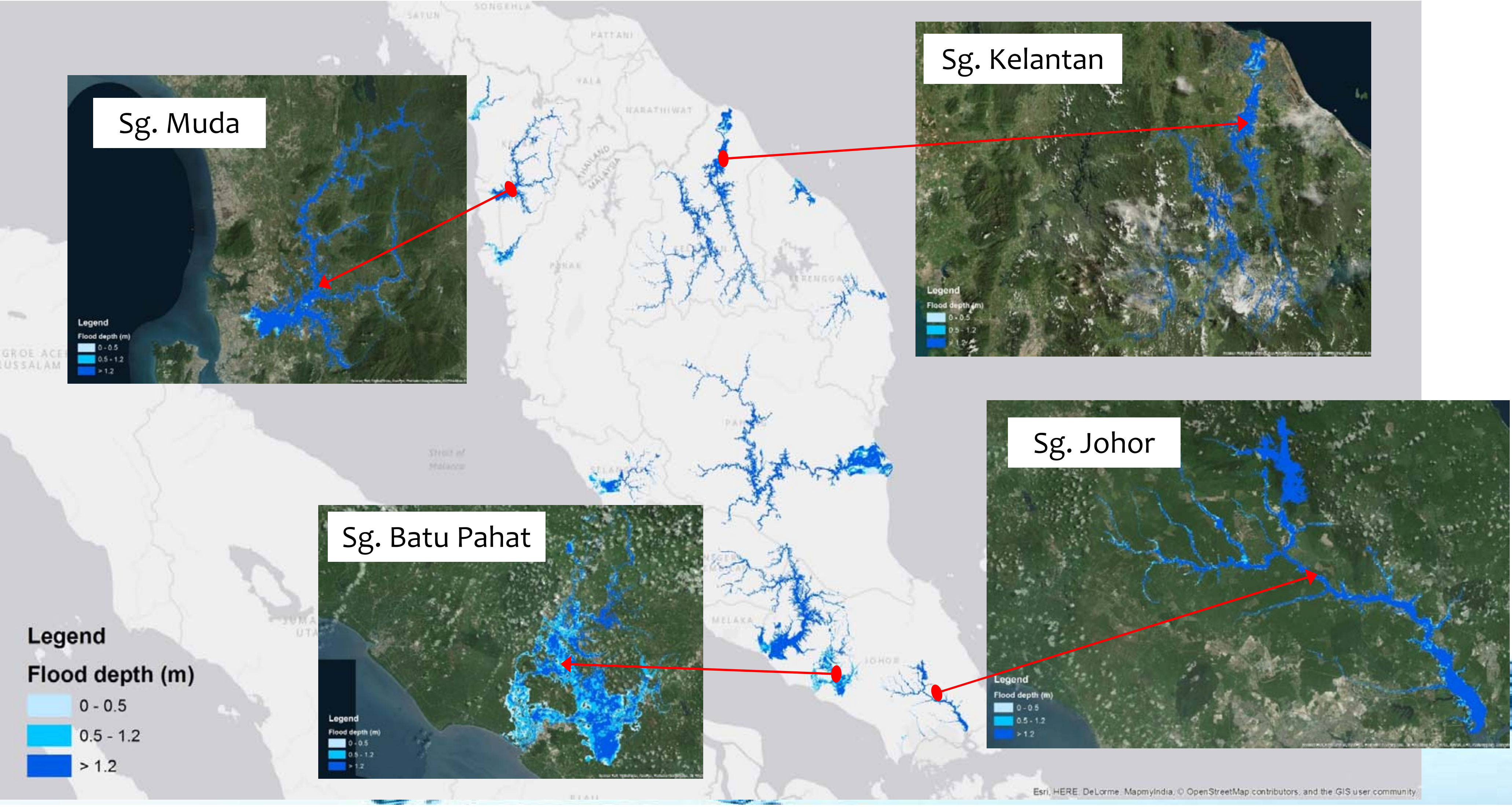
Kelantan Floods:
Dec 2014 & Jan 2015

Continuous heavy downpour & downstream flooding..
Properties & infrastructures destroyed..
25 deaths..

Kelantan Floods: Dec 2014 & Jan 2015

Continuous heavy downpour & coastal flooding..
Properties & infrastructures destroyed..
25 deaths..

Projected Flood Maps



Flooding: Direct Health Effects

Causes	Health Implications
Stream flow velocity; topographic land features; absence of warning; rapid speed of flood onset; deep floodwaters; landslides; debris flows.	Drowning Injuries
Contact with water	Respiratory diseases; shock; hypothermia; cardiac arrest.
Contact with polluted waters	Wound infections; dermatitis; conjunctivitis; gastrointestinal illnesses; ear, nose and throat infections; possible serious waterborne disease.
Increase in physical and emotional stress	Increase of susceptibility to psychosocial disturbances and cardiovascular incidences

Flooding: Indirect Health Effects

Causes	Health Implications
Damage to water supply and sewerage systems; insufficient water supply	Possible waterborne infections (e.g. enterogenic E coli, shigella; hepatitis A; leptosperiosis)
Disruption to transport systems	Food shortages; disruption of emergency services
Underground pipe disruption; dislodgement of storage tanks; overflow of toxic waste; release of chemicals; rupture of gasoline storage tanks	Potential acute or chronic effects from chemical pollution and air pollution.
Standing waters; heavy rainfall; expanded range of vector habitats	Vector borne diseases
Rodent and other pest migration	Possible diseases caused by rodents or other pests
Disruption of social networks; loss of property, jobs and family members/friends	Possible psychosocial disturbance
Cleaning up activities following floods	Electrocutions; injuries; lacerations; skin punctures
Destruction of primary food products	Food shortage
Damage to health services; disruption of 'normal' health service activities	Disruption of 'normal' health care services, insufficient access to medical care

PROJECTED DROUGHTS

DROUGHT IMPACTS

Malaysia has experienced several episodes of extreme droughts due to CC & El Nino

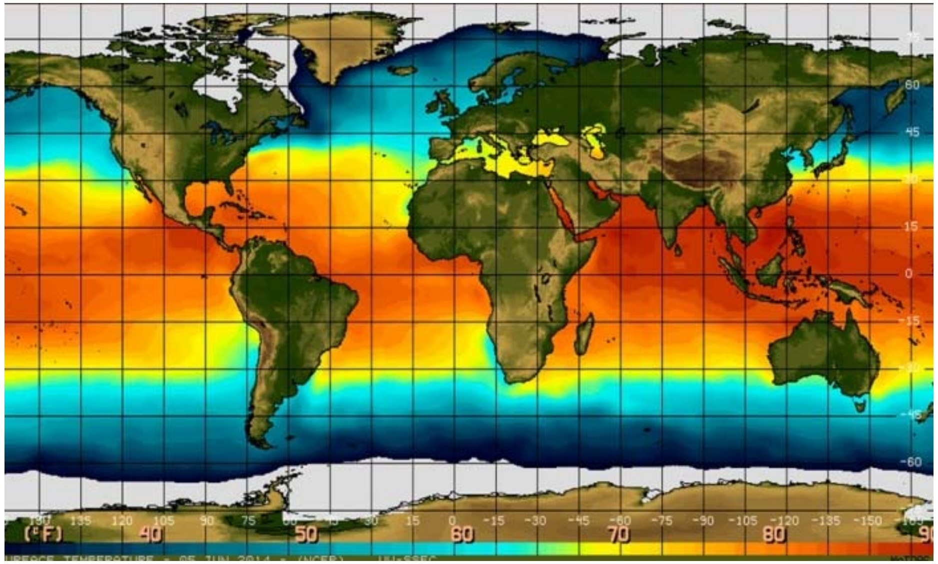
Droughts have caused water supply interruptions due to insufficient water resources

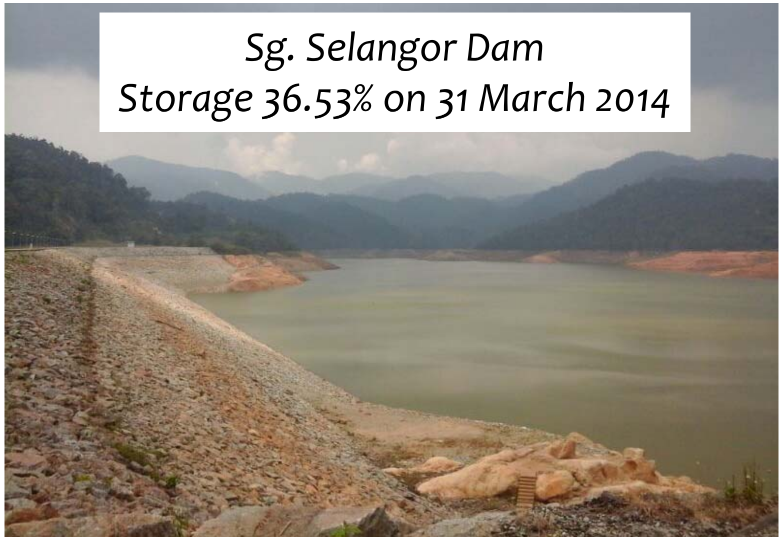
Nine water supply dams have experienced decline in water storages that reached critical levels (below 40% storage)

The other consequence of drought is water pollution

Drought – Klang Valley Water Crisis 2014…

Source: SREX Report (IPCC, 2011)





Due to El-Nino phenomenon..

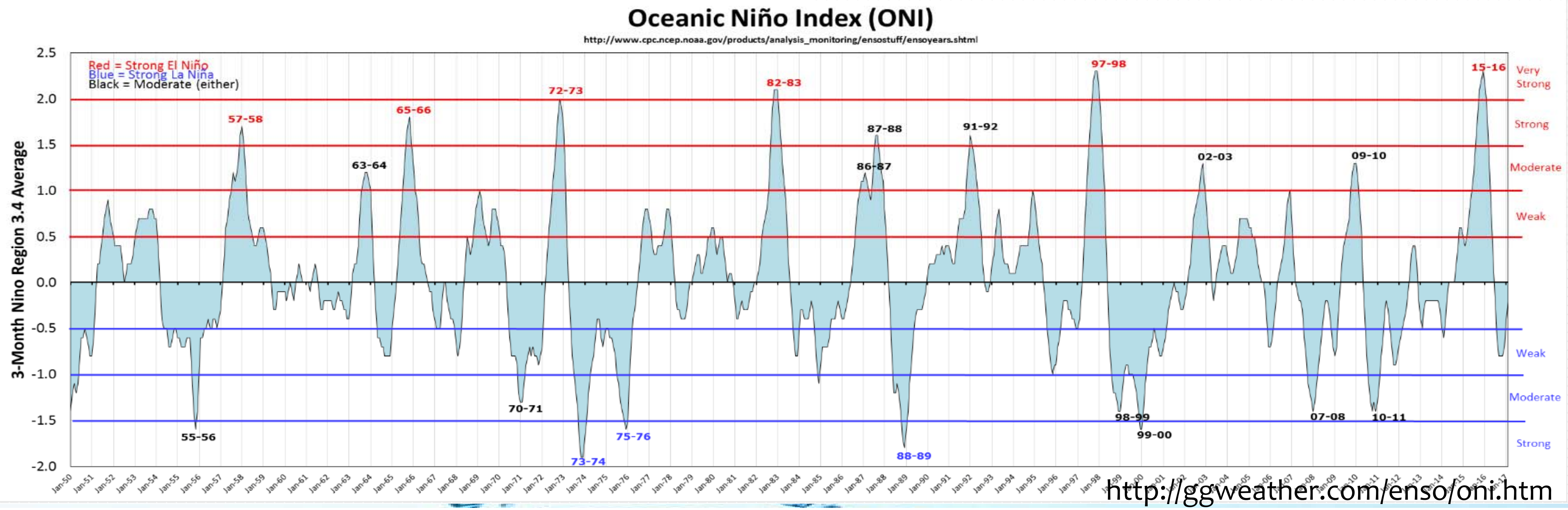
Worst water crisis in the state since the 1998 water crisis..

Water rationing for 3 months… millions affected..

Oceanic Nino Index

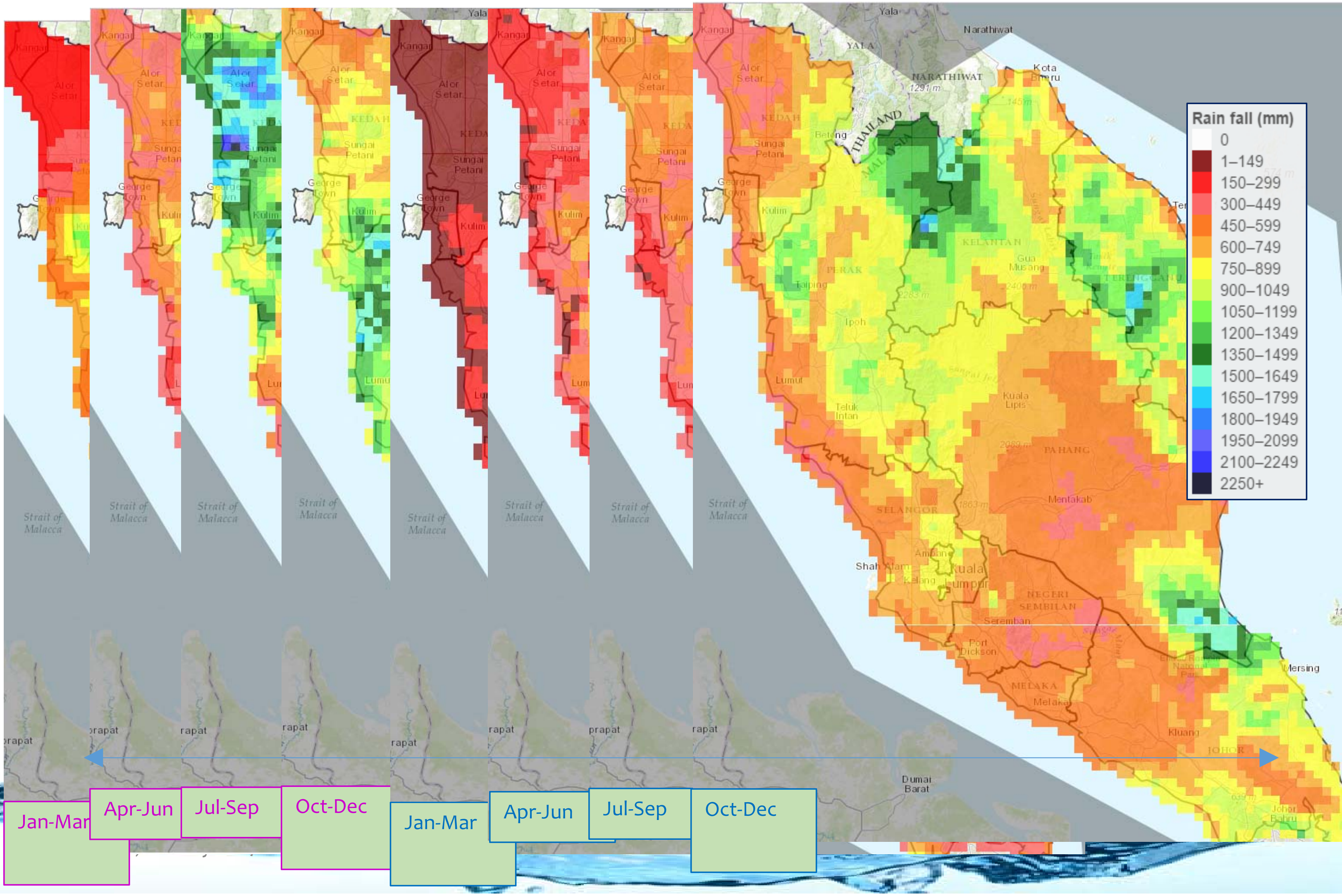
The Oceanic Niño Index (ONI) is NOAA's primary index for monitoring and ranking the relative strength of ENSO, the El Niño-Southern Oscillation. The ONI tracks the rolling 3-month average sea surface temperatures (SST) in the east-central tropical Pacific. When the index is 0.5°C or higher, El Niño conditions exist. When the index is -0.5°C or lower, Lal Niña conditions exist. The threshold is further broken down into Weak (with 0.5 to 0.9 SST anomaly), Moderate (1.0 to 1.4), Strong (1.5 to 1.9) and Very Strong (≥ 2.0) events.

El Niño				La Niña		
Weak	Mod	Strong	Very Strong	Weak	Mod	Strong
1951-52	1963-64	1957-58	1982-83	1950-51	1955-56	1973-74
1952-53	1986-87	1965-66	1997-98	1954-55	1970-71	1975-76
1953-54	1987-88	1972-73	2015-16	1964-65	1998-99	1988-89
1958-59	1991-92			1967-68	1999-00	
1968-69	2002-03			1971-72	2007-08	
1969-70	2009-10			1974-75	2010-11	
1976-77				1983-84		
1977-78				1984-85		
1979-80				1995-96		
1994-95				2000-01		
2004-05				2011-12		
2006-07				2016-17		

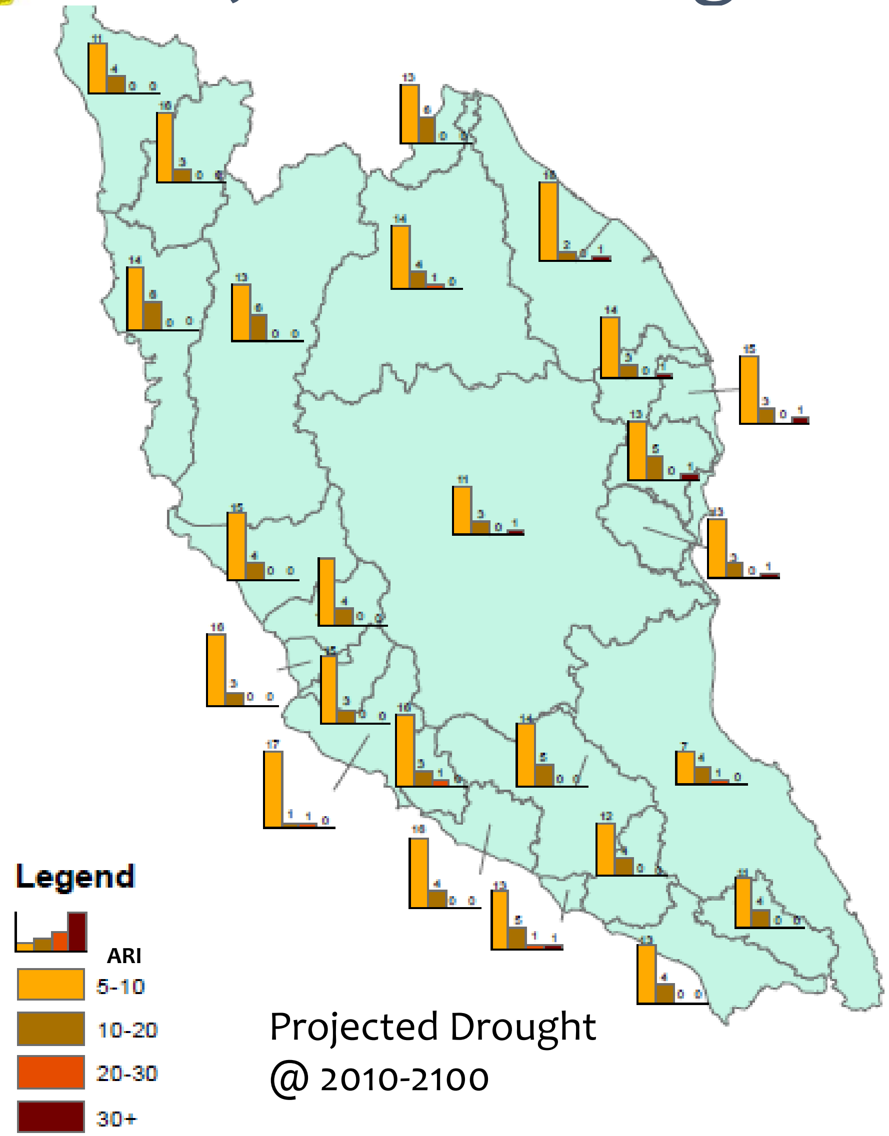


Droughts

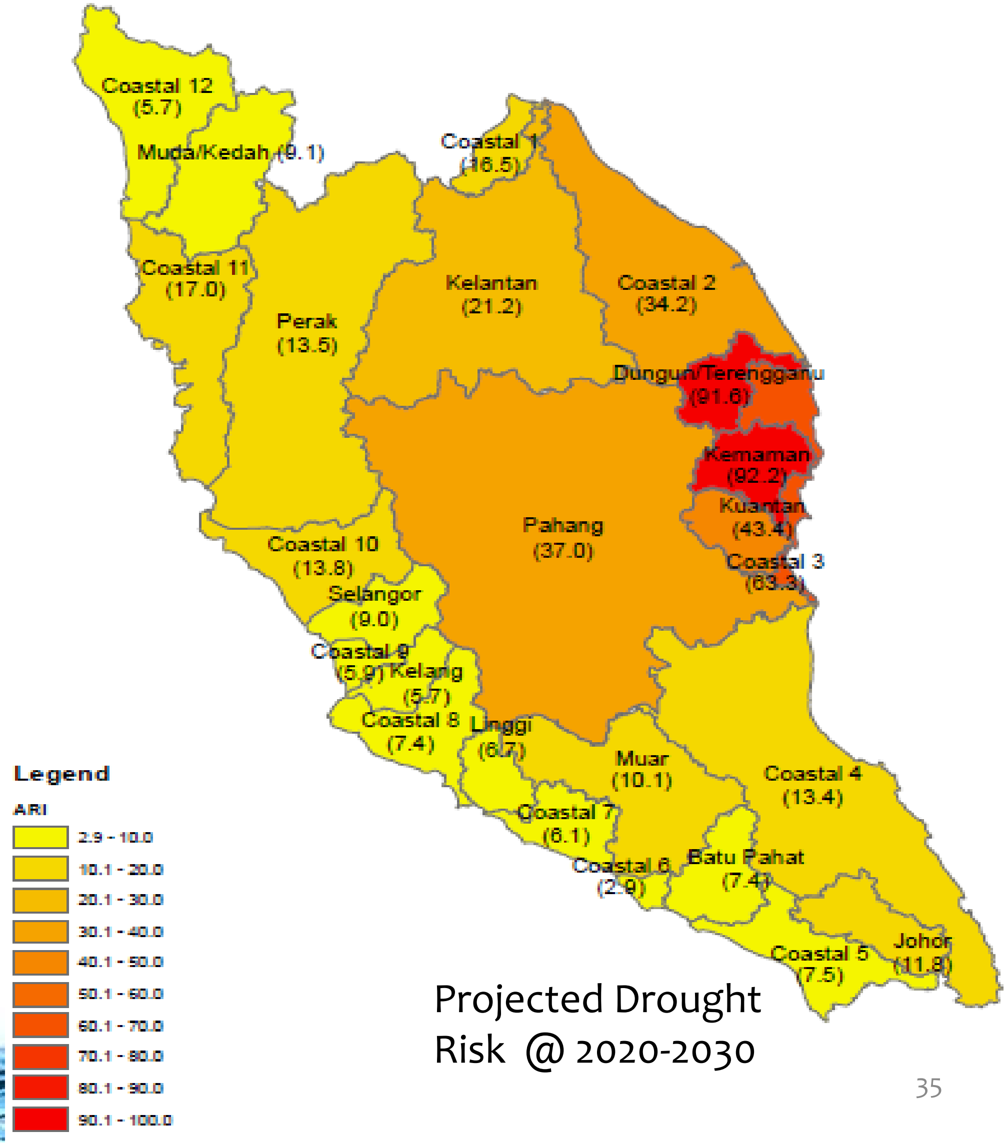
2016 2024



Projected Drought Occurences & Magnitudes



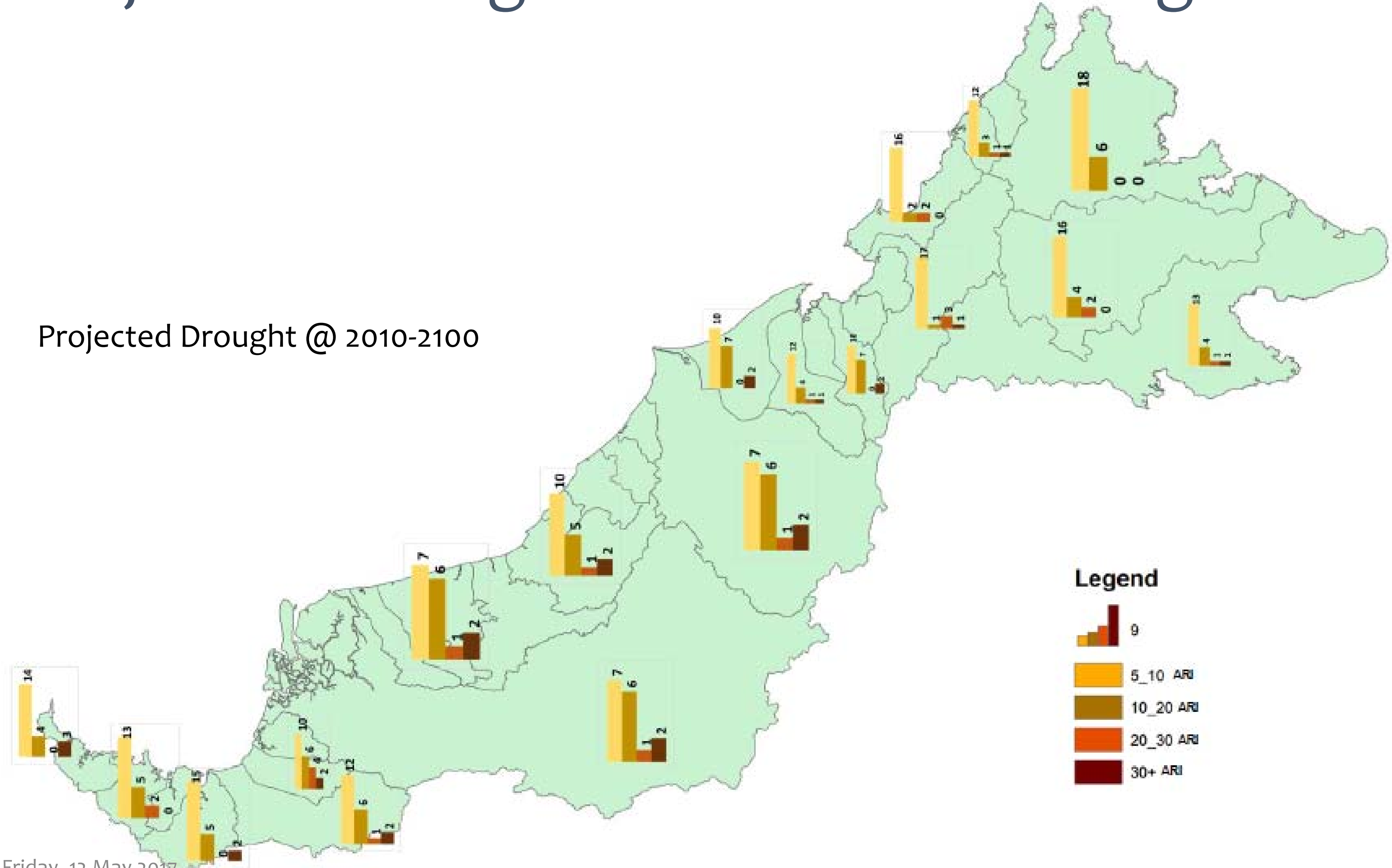
Projected Drought @ 2010-2100



Projected Drought Risk @ 2020-2030

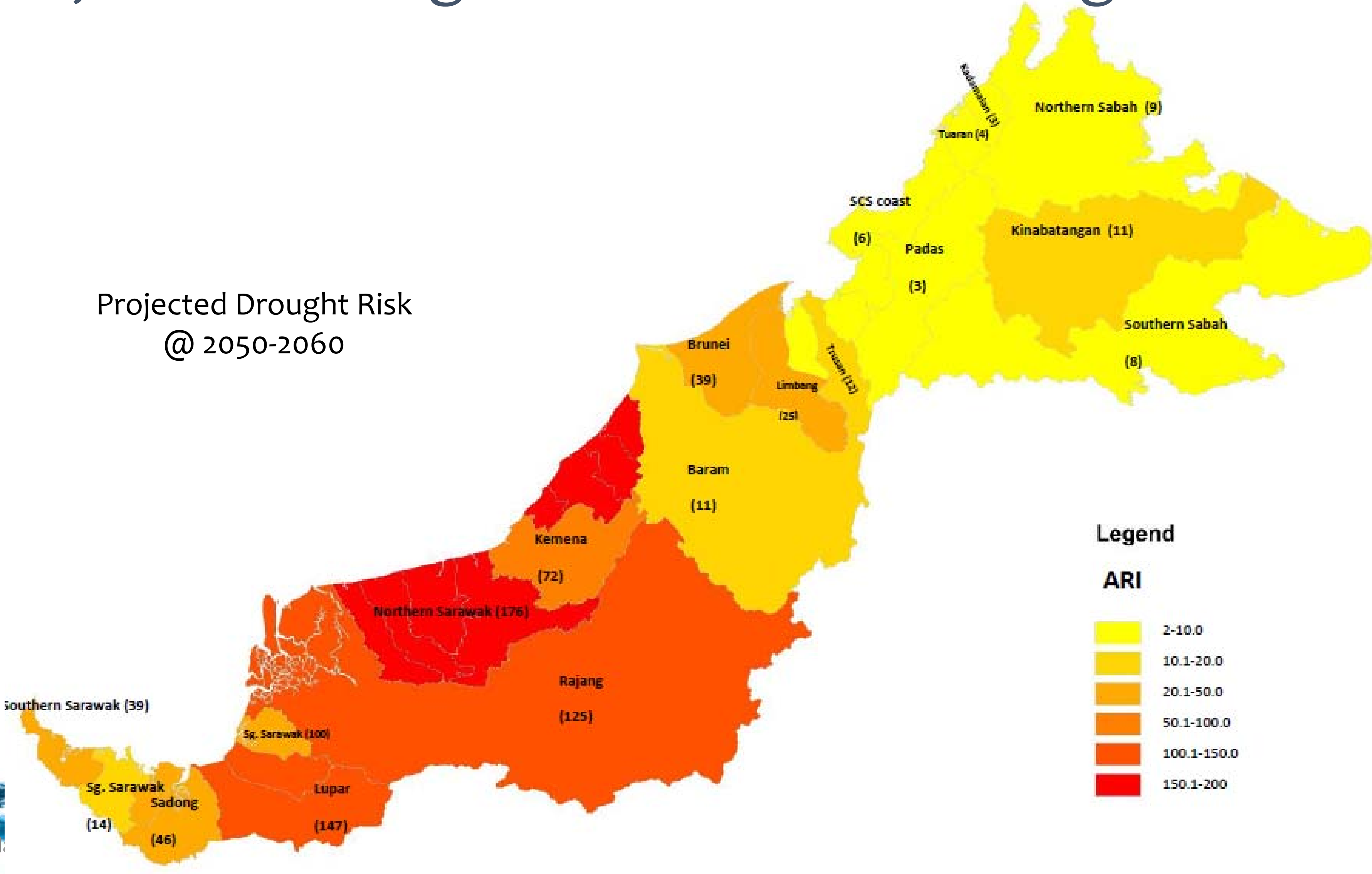
Projected Drought Occurences & Magnitudes

Projected Drought @ 2010-2100



Projected Drought Occurences & Magnitudes

Projected Drought Risk
@ 2050-2060



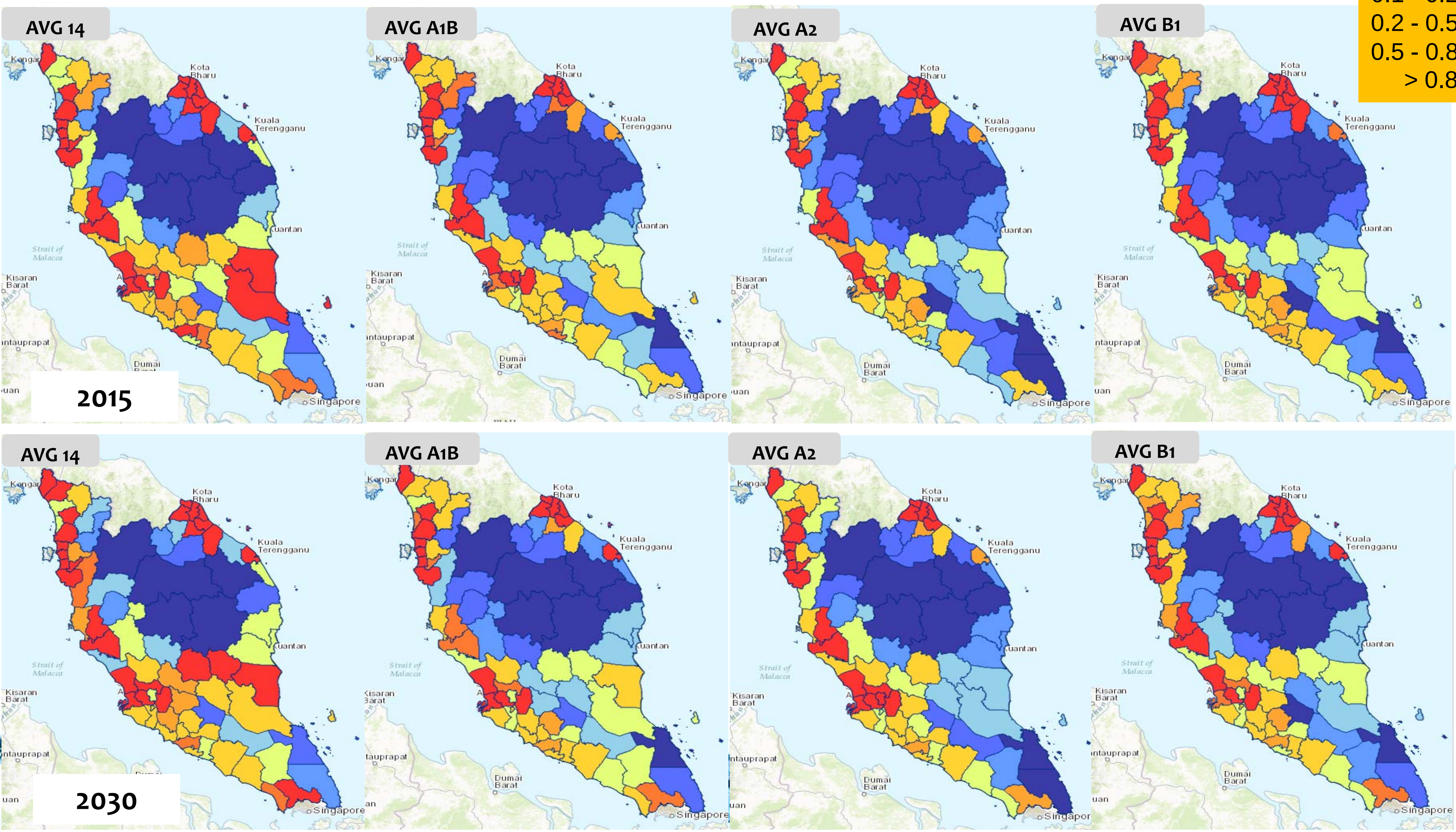
Impacts to Health from Increased Temperatures

- Direct impacts:
  a) **Heat cramps** – muscular pains and spasms
  b) **Heat exhaustion** – body fluids are lost through heavy sweating
  c) **Heat stroke** – is life threatening.
- Indirect impacts:
  a) Range of areas that can potentially be affected with gradual and extreme temperature increases
  b) Includes impacts on ecosystems, water, food, disease-carrying vectors, lifestyle and community resilience.

PROJECTED IMPACT ON WATER RESOURCES

Water Stress Index (WSI - 2015 & 2030)

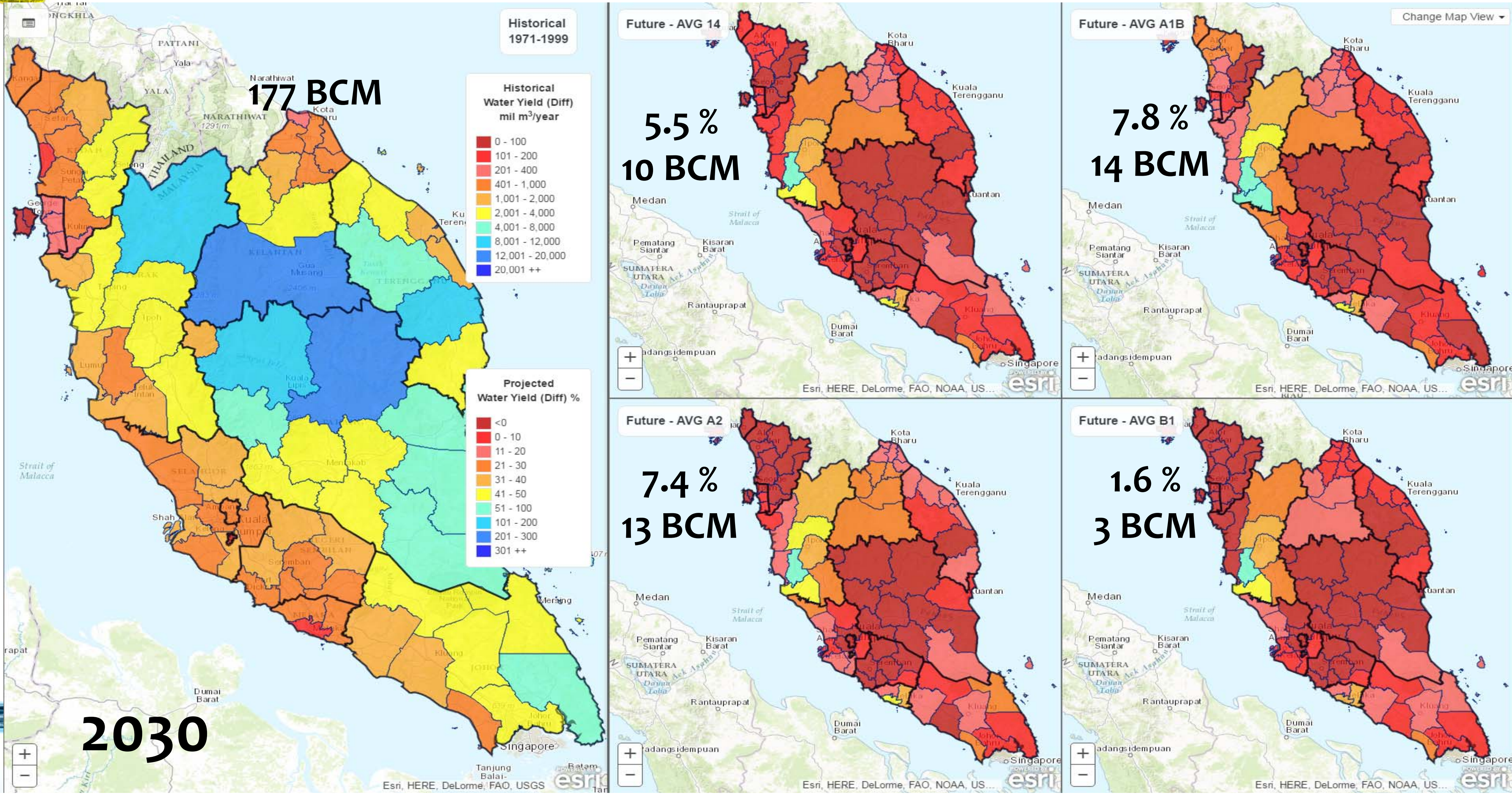
WSI
< 0.1: low
0.1 - 0.2: medium low
0.2 - 0.5: moderate
0.5 - 0.8: high
> 0.8: extremely high



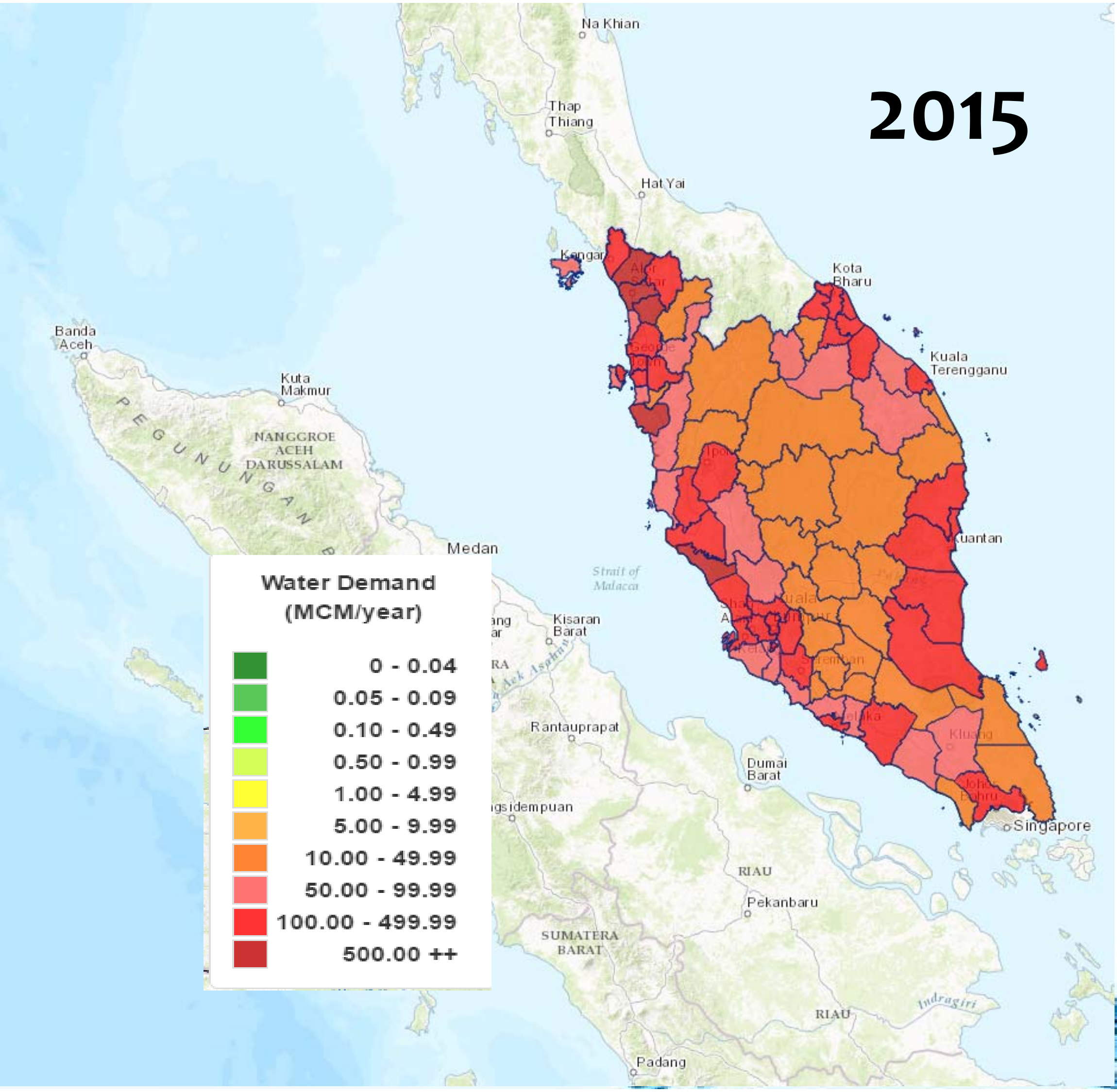
WSI Legend

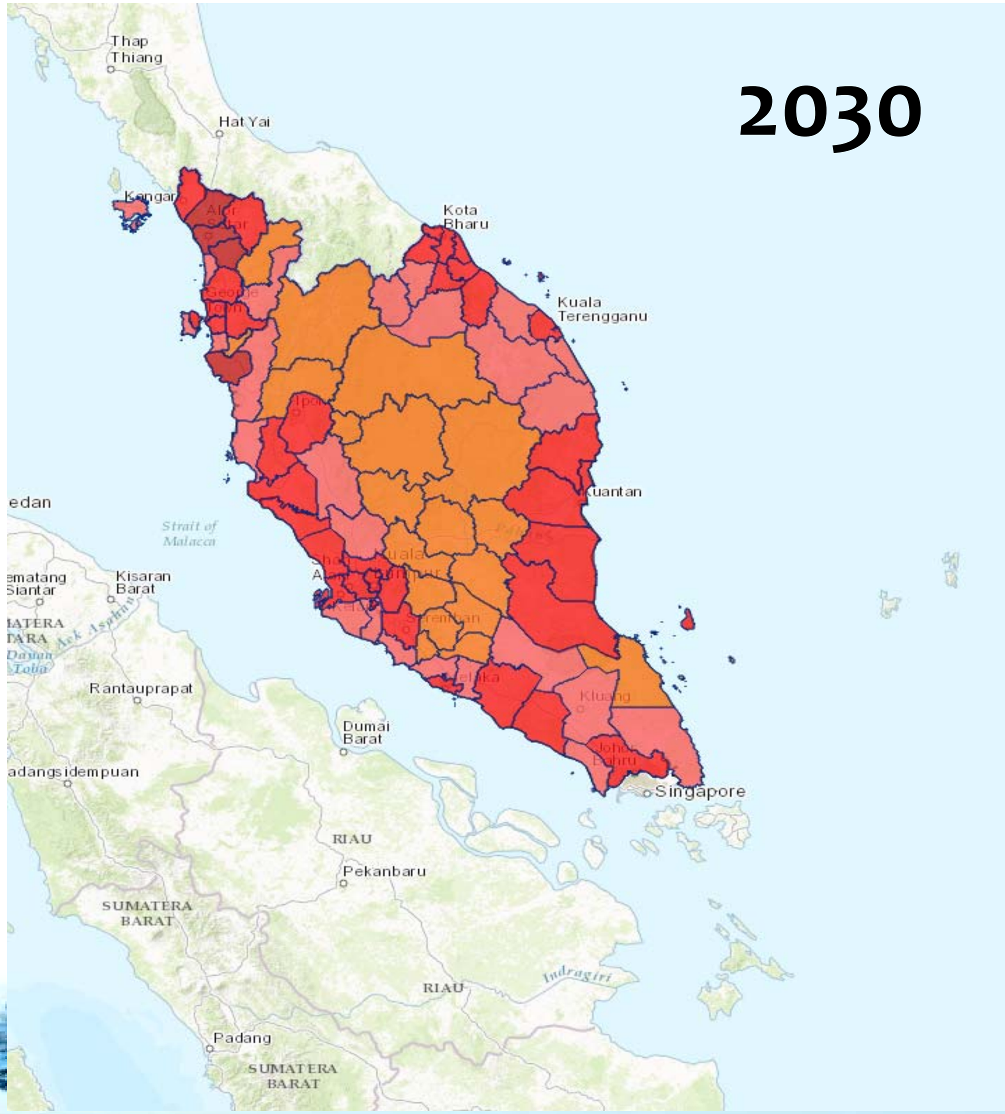
- < 0.02
- 0.02 - 0.04
- 0.05 - 0.09
- 0.10 - 0.19
- 0.20 - 0.49
- 0.50 - 0.79
- 0.80 - 0.89
- 0.90 - 0.95
- > 0.95

Water Yield & Water Yield Difference (2015 & 2030)

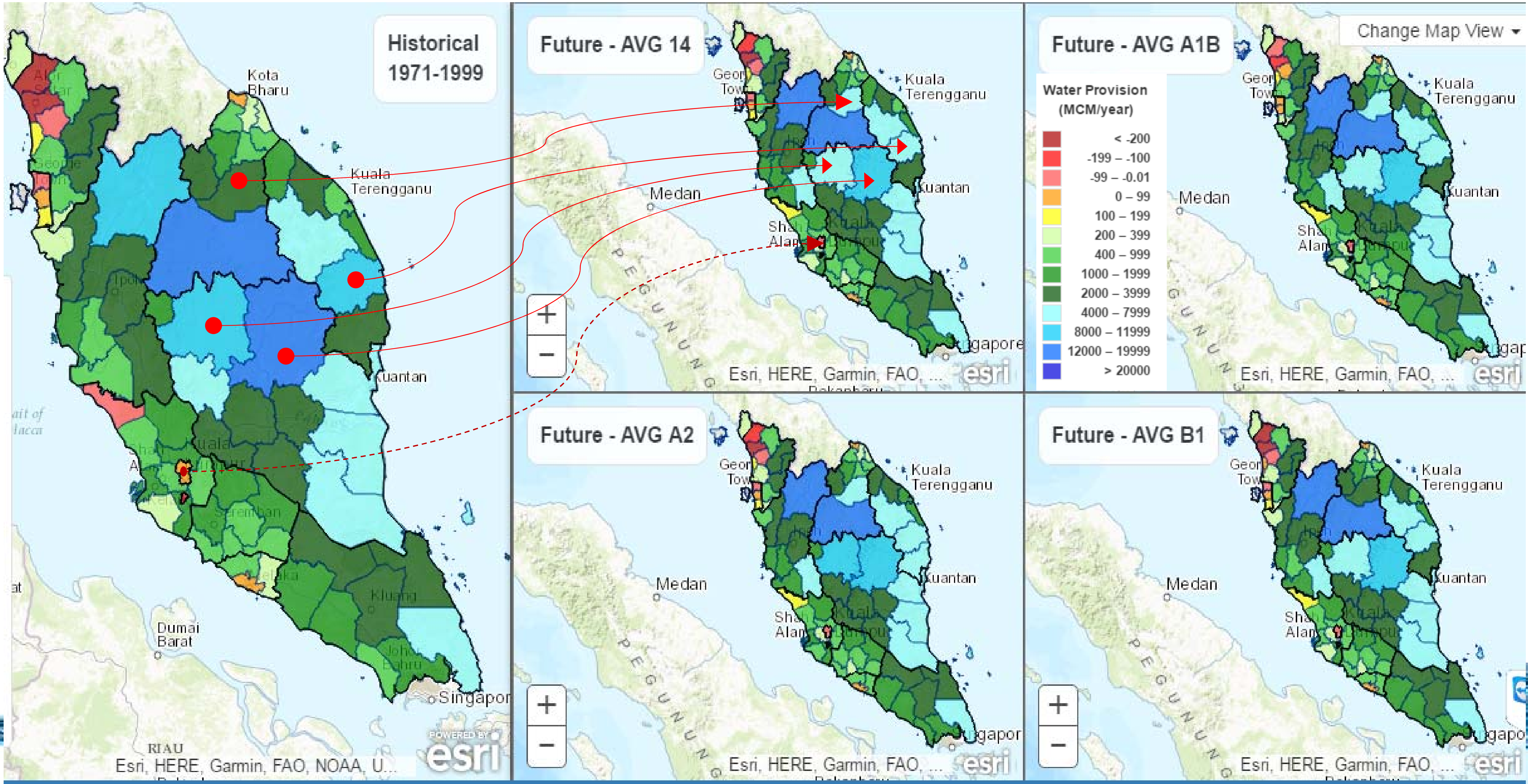


Water Demand (2015 & 2030)



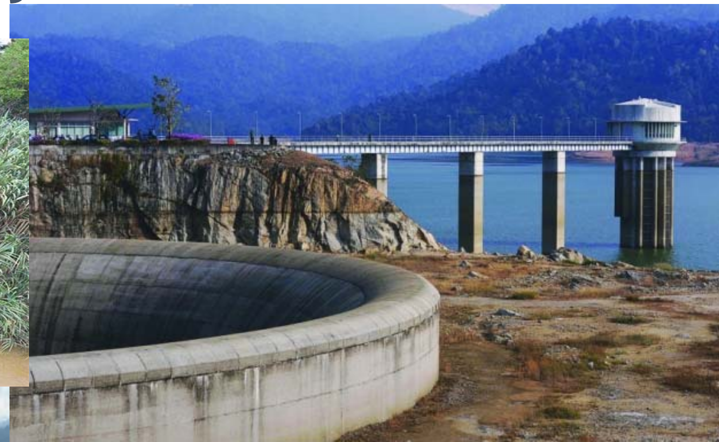


Water Provision (2030)



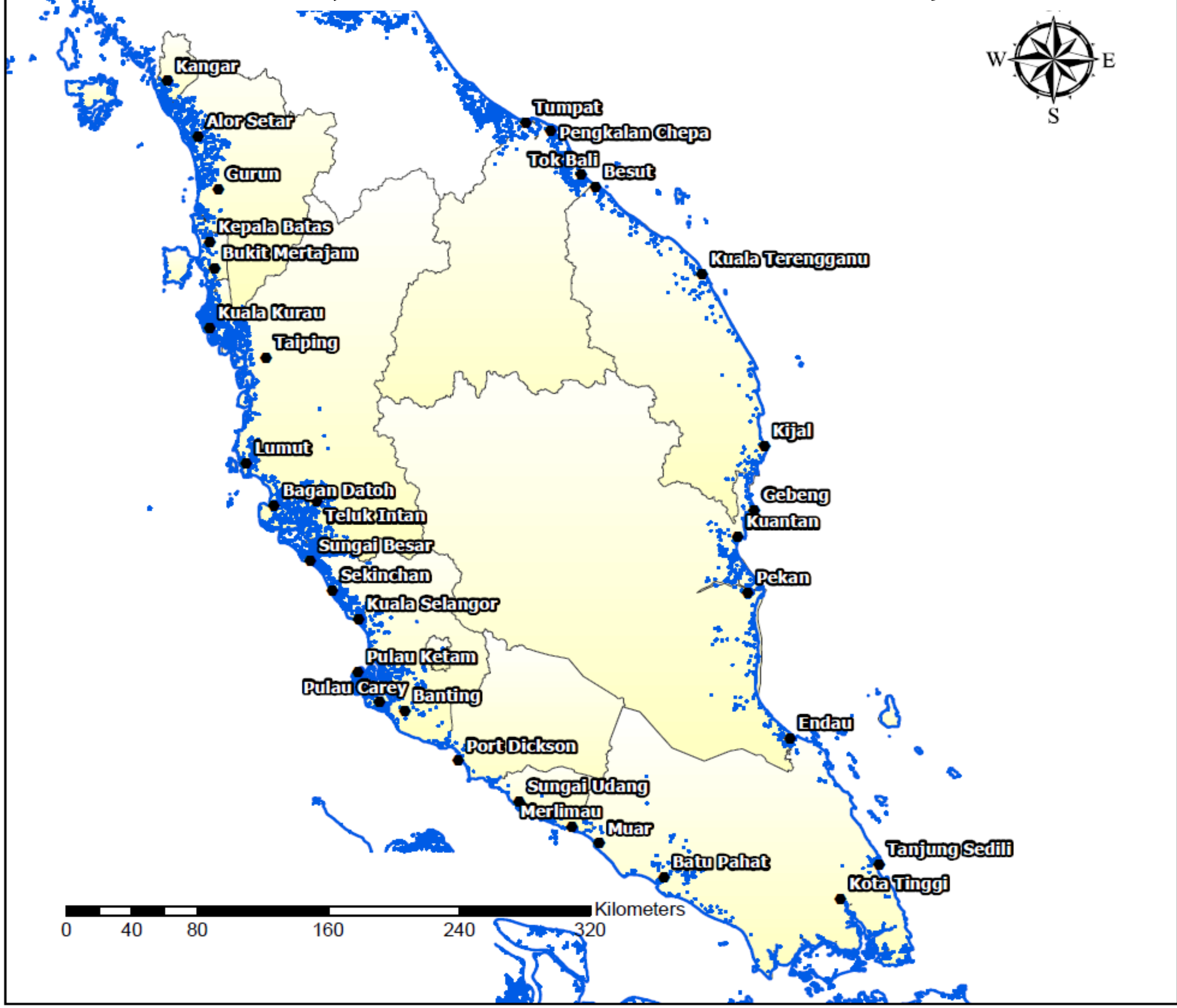
CC: Water Resources & Public Water Supply

- Changes in raw water supply
- Changes in raw water quality
- Risks to water infrastructure
- Degradation of watershed
- Coastal impacts
- Increased risk from pollution:
  - Increase nutrients and chemical contaminants
  - Toxic algal bloom



PROJECTED SEA LEVEL RISE

Projected SLR of 0.5 m for Peninsular Malaysia

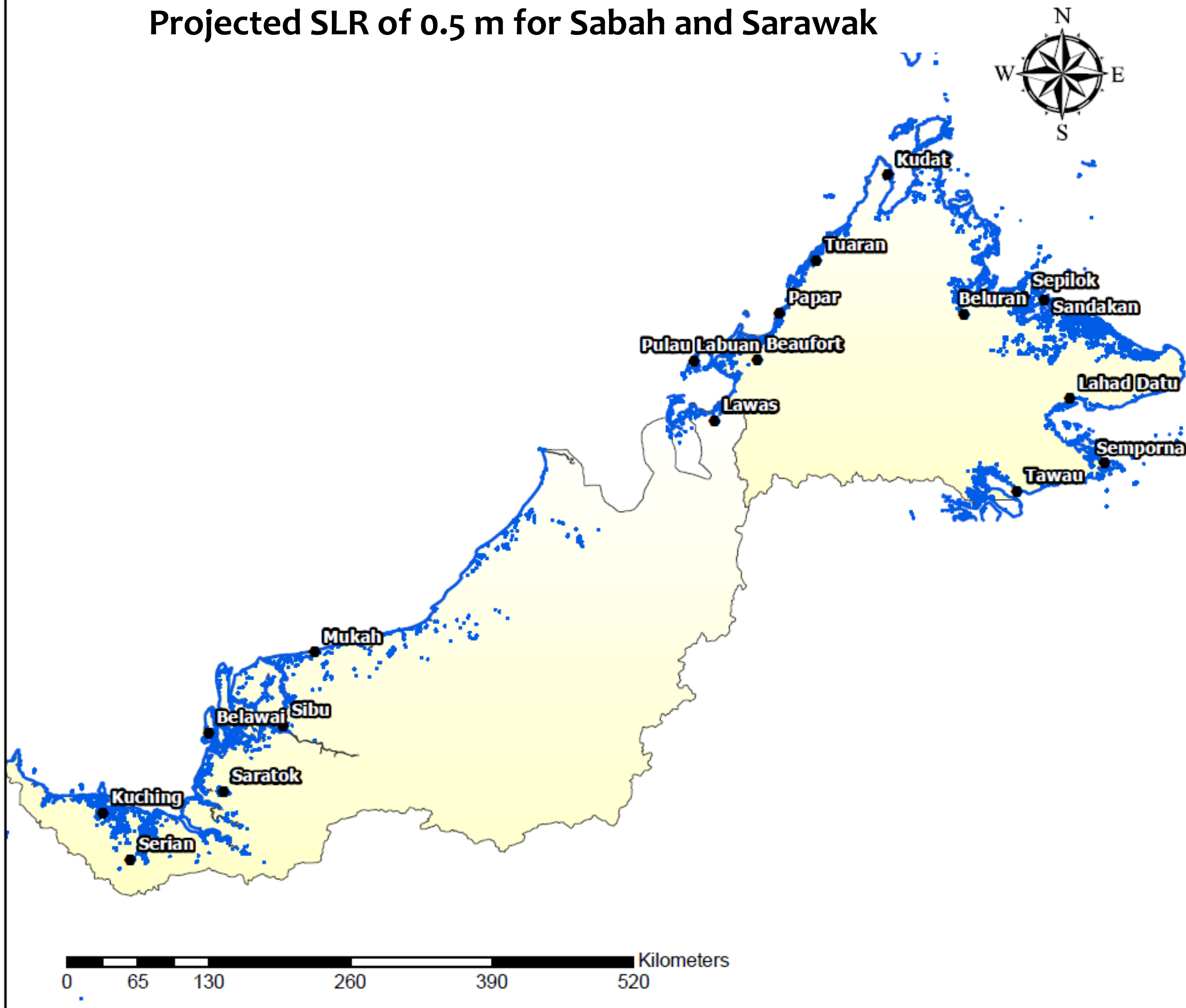


Notes:

Projected inundated areas = 1,583,429 ha (12.1 %)

Total land area = 13,059,800 ha

Projected SLR of 0.5 m for Sabah and Sarawak



Notes:

Projected inundated areas = 1,505,100 ha (7.6 %)

Total land area = 19,695,000 ha

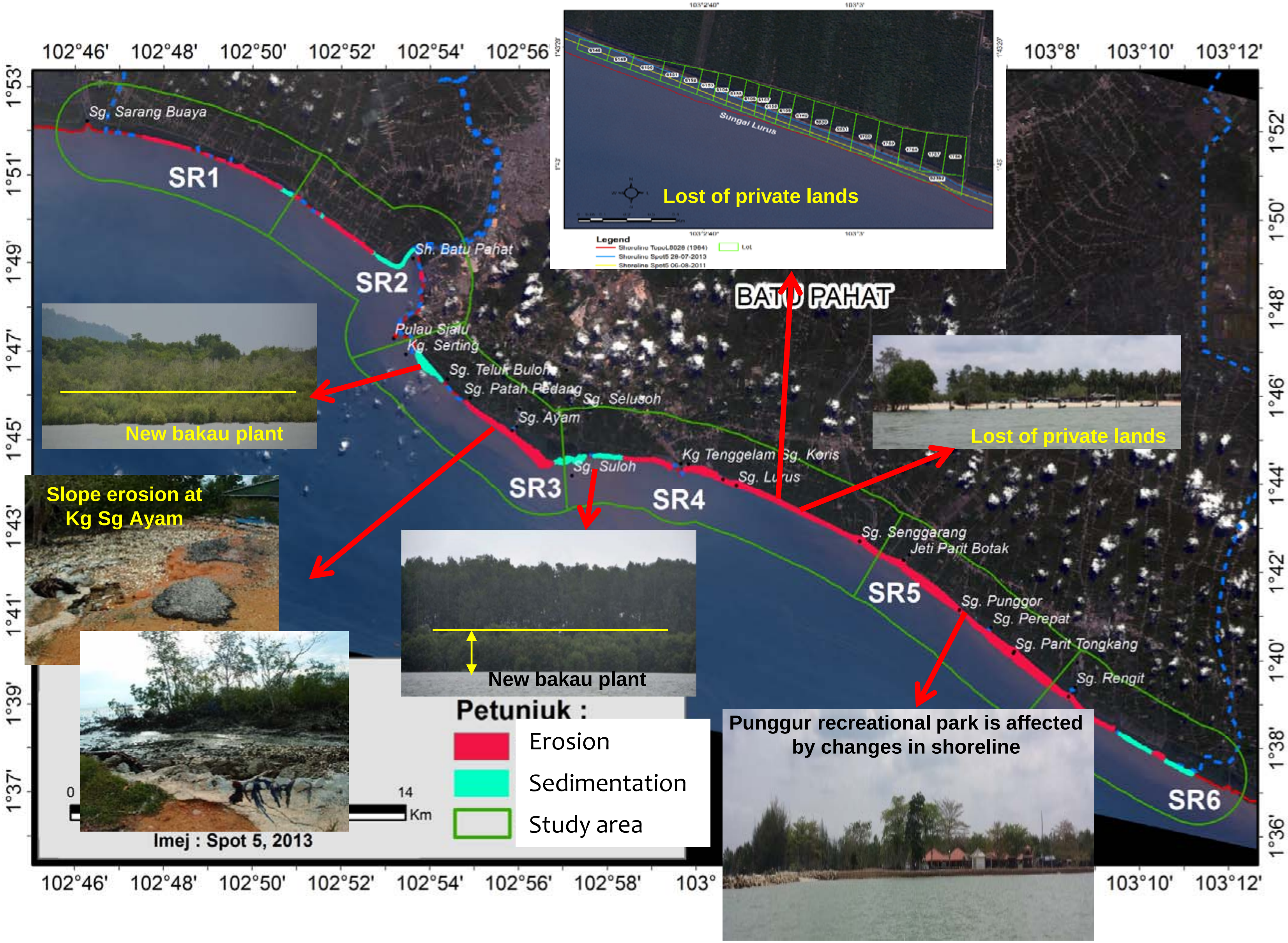
Case Study: SLR, Vulnerability Asessment @ Batu Pahat


Kg Sg Ayam - inundated by sea water during King Tide

Sea water inundated low lying areas consequent to overtopping of bunds

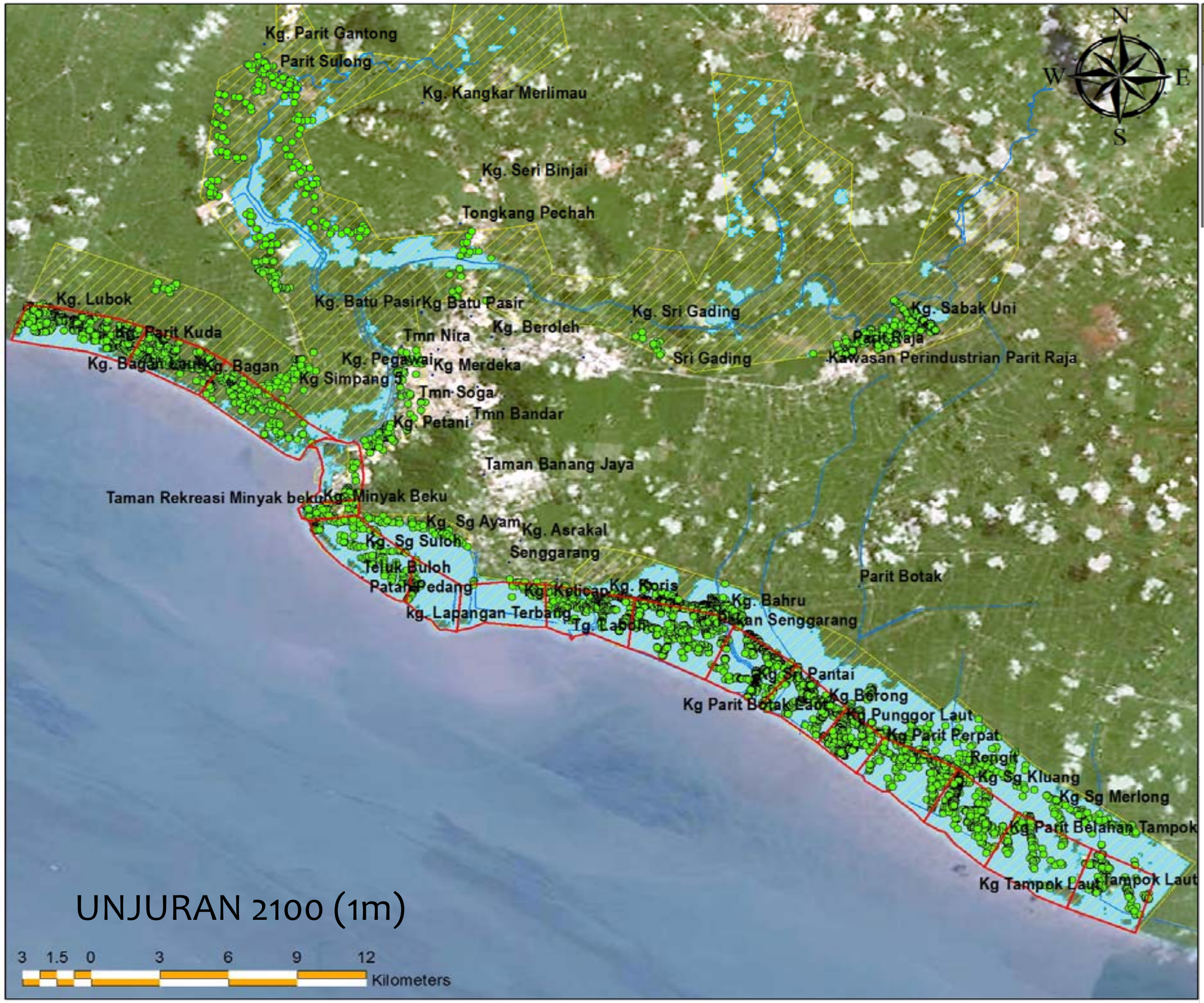

Buildings and slope structures at Teluk Serting are damaged by high tides

Punggur Recreational Park is impacted by sea water - saline intrusion extends to almost 10 m inland.


Lost of private lands
Sungai Lurus
Legend
BATU PAHAT
Sg. Sarang Buaya
SR1
SR2
SR3
SR4
SR5
SR6
Sh. Batu Pahat
Pulau Sjalu
Kg. Serting
Sg. Teluk Buloh
Sg. Patah Pedang
Sg. Selusoh
Sg. Ayam
Sg. Suloh
Kg Tenggelam
Sg. Koris
Sg. Lurus
Sg. Senggarang
Jeti Parit Botak
Sg. Punggor
Sg. Perepat
Sg. Parit Tongkang
Sg. Rengit
New bakau plant
Lost of private lands
Slope erosion at
Kg Sg Ayam
New bakau plant
Punggur recreational park is affected
by changes in shoreline
Petunjuk :
Erosion
Sedimentation
Study area
0
14
Km
Imej : Spot 5, 2013
102°46'
102°48'
102°50'
102°52'
102°54'
102°56'
102°58'
103°
103°8'
103°10'
103°12'
1°53'
1°51'
1°49'
1°47'
1°45'
1°43'
1°41'
1°39'
1°37'
1°52'
1°50'
1°48'
1°46'
1°44'
1°42'
1°40'
1°38'
1°36'

T

Risk Map of the Inundated Area



Notes:

Inundation depth:
1 m

Project affected people:
29,530 (76.1%)

Total population
38 ,790 ha

SUMMARY & WAY FORWARD

CC & Health

Health risks are influenced by both 'natural climate variability' and by human-induced CC

Climate change impacts could be enhanced by other environmental changes

- Heat–related illnesses and deaths
- Water-borne diseases from floods
- Impacts from more severe storms
- Psychosocial impacts from floods/ droughts/ storms
- Respiratory illnesses from forest fires / haze

Direct Impact:

- Heatwaves
- Floods
- Storms
- Drought
- Fires

+

Indirect Impact:

- Physical Changes
- Urban Air Pollution
- Biological Changes
- Ecosystem Changes – fisheries

- **Changes in drinking water quality and quantity**
- **Food security - changing animal distributions**

→

Health Impacts

- Social, Economic & Demographic Disruption

Prepare Climate Resilience Framework

- Integrate & coordinate non-climatic and climatic forcing issues
- Build resilience or adapt to CC impacts
- Make decisions on how to use CC information
- Communicating results, uncertainties and analyses to Decision-Makers

Intensify Vulnerability and Adaptation (V&A) Framework for Health

FRAME & SCOPE ASSESSMENT

- Define geographical region & health interests
- Identify policy assessment
- Establish management plan & stakeholder process
- Develop communication plan

ASSESSMENT

- Vulnerability – Current burden of diseases and health protection programmes
- Future Impacts – changing burden without CC, projected health impacts of CC
- Adaptation – identify & prioritize additional interventions, identify resources and barriers to implementation

MANAGE & MONITOR RISKS

- Communicate, Plan and Implement
- Monitor & Evaluate

TWG on Vulnerability & Adaptation for TNC

Main Objective:
To produce a chapter on V & A Assessment for the TNC Report

The 5 Sub-Working Groups

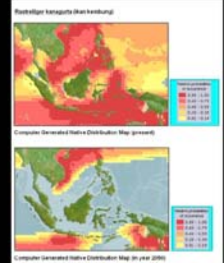
- Water & Coastal Resources
- Agriculture, Forestry and Biodiversity
- Infrastructure
- Energy
- Public Health

Water & Coastal Resources (JPS/28)

No.	Area of Concern	Threats
1	Reservoir Storage & Dam Security	Flood, Drought
2	Food Security (Granary Areas)	Flood, Drought, Sea Level Rise
3	Flood Risk Management	Flood
4	Groundwater Security	Sea Level Rise
5	Coastal Resources Security (Coastal Erosion)	Sea Level Rise
6	Coastal Resources Security (Capture Fish)	Sea Surface Temperature Rise

6. Coastal Resources Security (Capture Fish)
Future Projections (SST Rise)

- A climate change projection showing the occurrence of Indian Mackerel (*ikan kembung*) in the South China Sea region at present and in 2050 (under IPCC SRES A1B scenario) shows that there will be a decrease in mackerel distribution by 2050.
- Another study by Razib & Mustapha, (2013) shows that SST increases of 1.8, 2.6 and 3.3°C will result in the decrease of R. kanagurta (Indian Mackerel) in South China Sea.



Energy (KeTTHA/7)

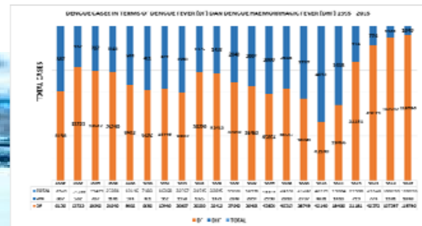
Total of Transmission Tower in Peninsular Malaysia	No. of Transmission Tower located in flood prone area base on Flood inundation Map	No. of Transmission Tower located in flood prone area base on projected flood for 9 river basin		
		Baseline	2030	2050
33,668	13,081 (38.9%)	723 (2.1%)	908 (2.7%)	975 (2.9%)

Public Health (IMR/3)

Table 1: Primary Health Clinics (PHC) affected by flooding at Baseline and ARI-20, 100 & 500

STATE	RTP								TOTAL
	Baseline		20		100		500		
	n	(%)	n	(%)	n	(%)	n	(%)	n
JOHOR	80	85.1	5	5.3	5	5.3	4	4.3	94
KEDAH	44	77.2	5	8.8	6	10.5	2	3.5	57
KELANTAN	58	73.4	10	12.7	5	6.3	6	7.6	79
MELAKA	24	82.8	1	3.4	2	6.9	2	6.9	29
NEGERI SEMBILAN	45	97.8	-	-	1	2.2	-	-	46
PAHANG	65	79.3	5	6.1	9	11.0	3	3.7	82
PERAK	65	77.4	9	10.7	6	7.1	4	4.8	84
PERLIS	7	77.8	-	-	1	11.1	1	11.1	9
PULAU PINANG	24	80.0	1	3.3	2	6.7	3	10.0	30
SABAH	79	79.8	9	9.1	6	6.1	5	5.1	99
SARAWAK	120	60.9	51	25.9	17	8.6	9	4.6	197
SELANGOR	57	78.1	5	6.8	5	6.8	6	8.2	73
TERENGGANU	39	86.7	-	-	5	11.1	1	2.2	45
W.P. KUALA LUMPUR	9	75.0	1	8.3	1	8.3	1	8.3	12
W.P. LABUAN	1	100	-	-	-	-	-	-	1
W.P. PUTRAJAYA	3	100	-	-	-	-	-	-	3
TOTAL	720	76.6	102	10.9	71	7.6	47	5.0	940

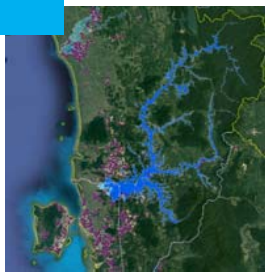
940 Primary Health Clinics (PHC) currently available in Malaysia, 102 (10.9%) have risk of flooding in 20-year ARI; whilst, 71 (7.6%) and 47 (5.0%) PHC's have risk of flooding in 100-year ARI and 500-year ARI, respectively.



Infrastructure (JKR/18)

Sub-sectors:

- Building
- Road & drainage
- Transportation
- Utility
- Solid waste



Agriculture, Forestry & Biodiversity (JPSM/14)

AFB Sub group (JPSM)

- Agriculture (MARDI)
- Forestry (JPSM)
- Biodiversity (Perhilitan)

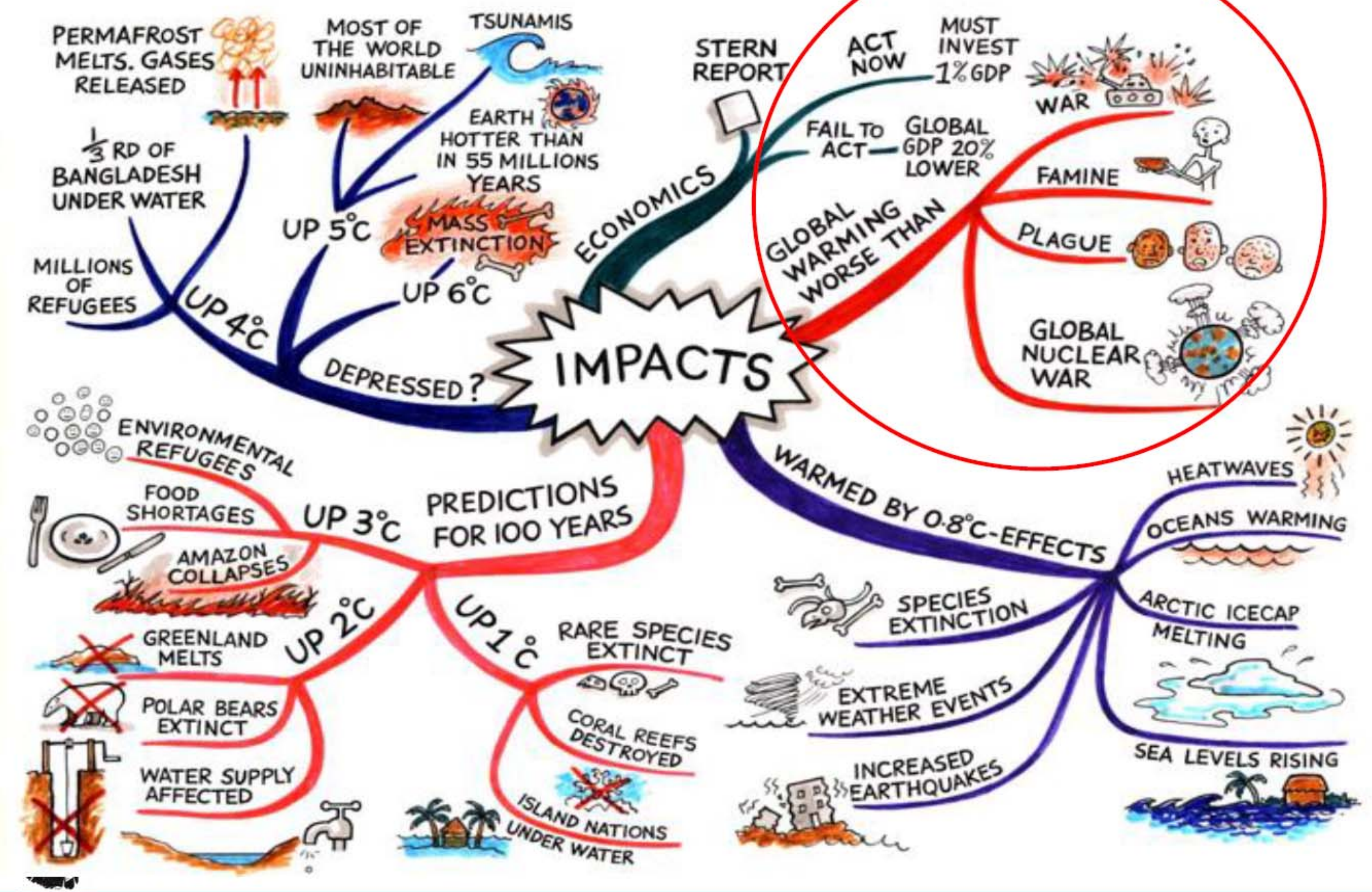
Oil palm yields could ▼ by ≈ 30 % when temperatures ▲ 2°C above optimum levels and rainfall ▼ 10 %

Temp. ▲ of 2°C will reduce rice yield by 13 %. Occurrence of floods could ▼ yields by as much as 80 %.

▲ in annual temp. above 30°C coupled with a reduction in rainfall < 1,500mm will resulting in up to a 10 % ▼ in yields.

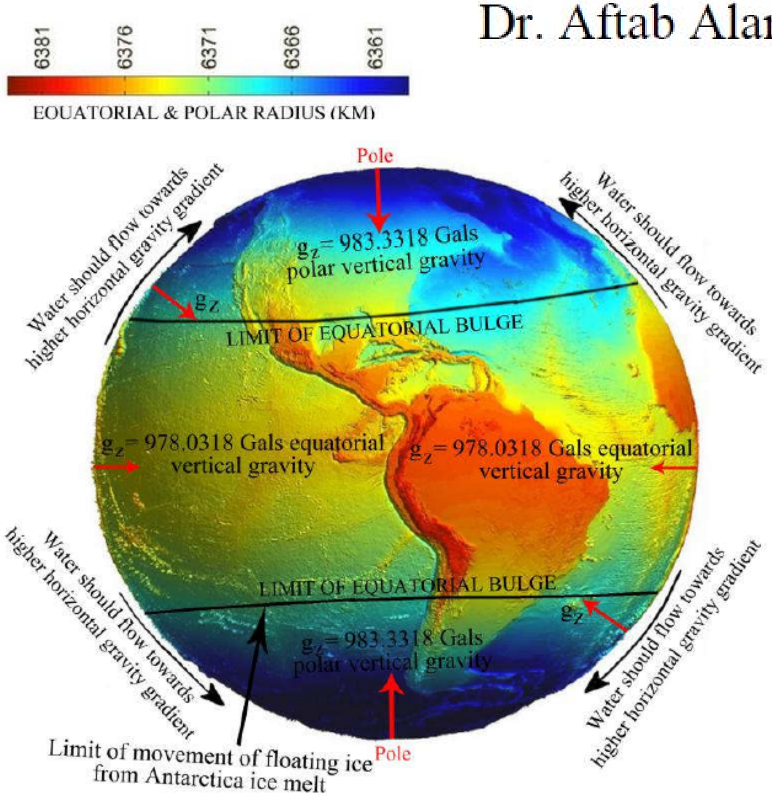
An annual rainfall exceeding 2,500 mm will ▼ yields due to higher fungus incidence.

Climate change



Why would sea-level rise for global warming and polar ice-melt?

Dr. Aftab Alam Khan, Professor, Department of Geology, Dhaka University, Bangladesh



Force of gravity (g_z) (red arrows) is everywhere normal to this surface, or the plumb line is vertical at all points directed to the center of the earth having maximum at the poles and minimum at the equator. Two components work against sea level rise i.e., greater gravity attraction of the polar region and the lesser gravity attraction of the equatorial region.

Conclusion

Due to low gravity in the region of equatorial bulge and high gravity in the region of polar flattening, melt-water would not move from polar region to equatorial region. Melt-water of the floating ice will reoccupy volume of the displaced water by the floating ice causing no sea-level rise.

THANK YOU

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