Climate change and its impacts in the ASEAN region

Third Program of China-ASEAN Academy on Ocean Law and Governance

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Outline

1. IPCC
2. ASEAN
3. Climate change
4. Coast
5. Freshwater
6. Food security
7. Human settlements
8. Adaptation

1. IPCC

IPCC

Body

- **Created in 1988 by WMO and UNEP. Has 195 governments that commission assessments performed by the international community on the state of human knowledge of climate & climate change.**

- **Role : to assess on a comprehensive, objective, open & transparent basis the scientific, technical & socio-economic information relevant to understanding scientific basis of risk of human-induced climate change, its potential impacts & options for adaptation & mitigation.**

- **IPCC assessments : scientific basis for governments at all levels to develop climate related policies, & they underlie negotiations at the UN Climate Conference (UNFCCC, United Nations Framework Convention on Climate Change).**

IPCC Assessment Reports

Work

- **1990 : First Assessment Report (FAR).**
- **1995 : Second Assessment Report (SAR).**
- **2001 : Third Assessment Report in (TAR).**
- **2007 : Fourth Assessment Report (AR4).**
- **2014 : Fifth Assessment Report (AR5).**

- **Currently, the assessment reports are structured in three parts, one for each Working Group. Each WG's contribution comprises a Summary for Policymakers (SPM), a Technical Summary (TS) & an underlying assessment report.**

- **All sections of each report undergo an exhaustive & intensive review process by experts & governments, which takes place in three stages: first review by experts; second review by experts & governments; third review by governments.**

- **Also produces Special Reports, methodology reports & technical papers, focusing on specific issues related to climate change.**

WGs and Task Force

Working Groups

- **WGI : assesses physical scientific aspects of climate system & climate change.**
- **WGII : assesses vulnerability of socio-economic & natural systems to climate change & options for adapting to it.**
- **WGIII : assesses options for mitigation climate change through limiting or preventing GHG emissions & enhancing activities to remove them.**
- **Task Force : to develop & refine internationally-agreed methodology & software for calculation & reporting GHG emissions.**

WGII AR5

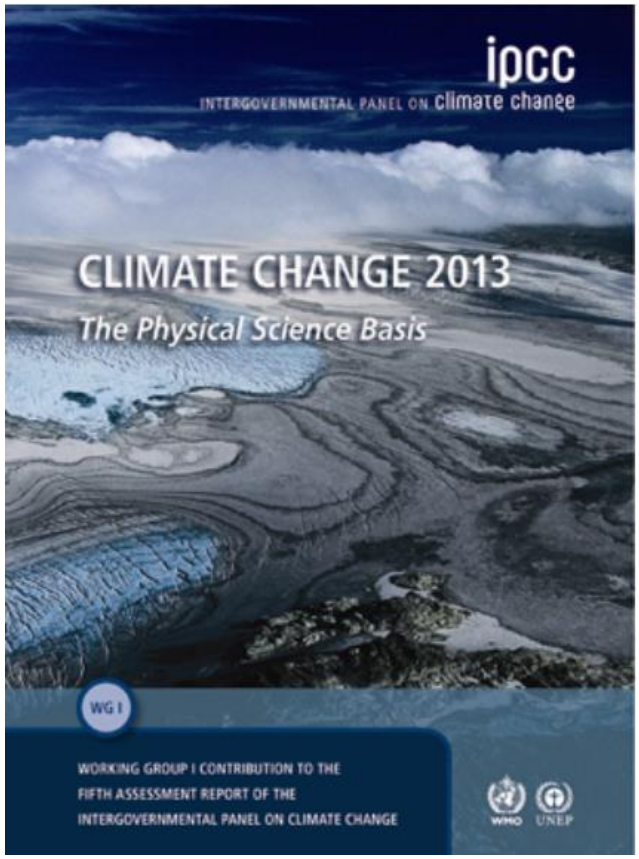
AR5 WGII

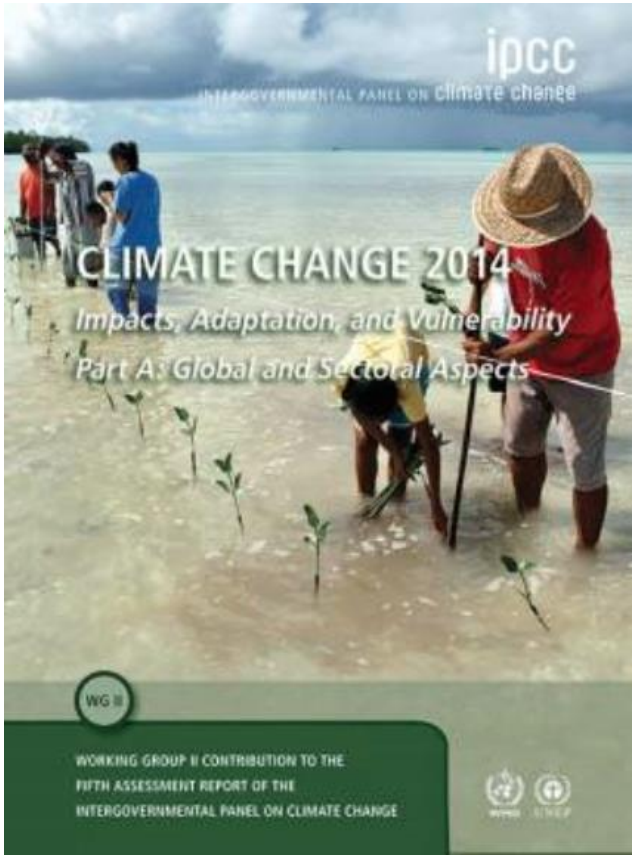
- **242 Lead Authors (about 60 are CLAs) & 66 Review Editors from 70 countries : selection criteria include expertise, differing viewpoints & perspectives, geographic balance, gender balance, & ensuring involvement of new experts in accordance to agreed-upon IPCC guidelines. Supplemented by 436 Contributing Authors from 54 countries.**

- **Undergone two extensive reviews : totaling over 50,000 comments from 1,729 expert reviewers from 84 countries & 49 governments.**

- **Large knowledge base. Substantial larger knowledge base : 30 chapters (from 20 in AR4); additional 4 on adaptation; 4 on livelihoods & poverty, human security, urban & rural areas; 2 on oceans. Two parts; part 1 on global & sectoral aspects; part 2 on regions. Over 12,000 scientific references.**

AR5 reports


ipcc
INTERGOVERNMENTAL PANEL ON climate change
CLIMATE CHANGE 2013
The Physical Science Basis
WG I
WORKING GROUP I CONTRIBUTION TO THE
FIFTH ASSESSMENT REPORT OF THE
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
WMO UNEP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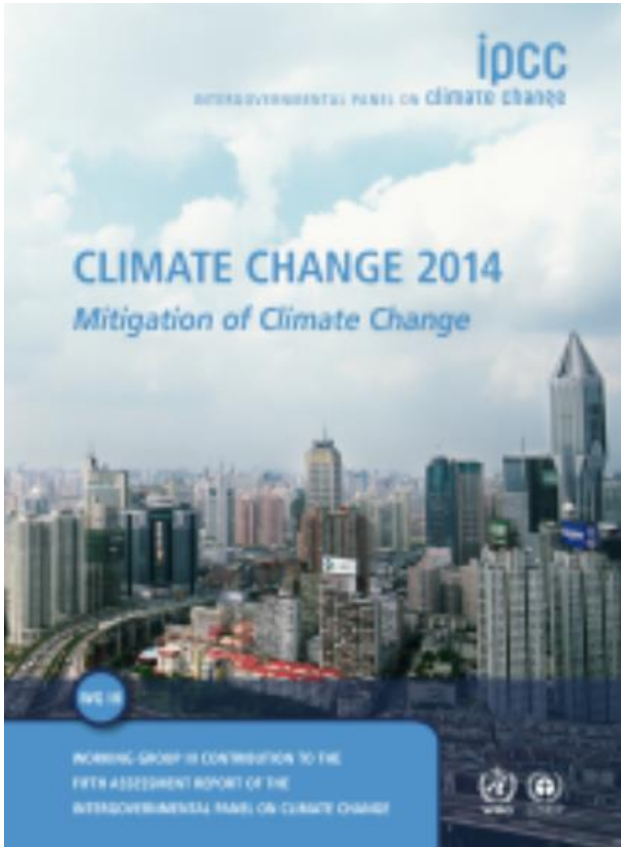
CLIMATE CHANGE 2014
Impacts, Adaptation, and Vulnerability
Part A: Global and Sectoral Aspects
WG II
WORKING GROUP II CONTRIBUTION TO THE
FIFTH ASSESSMENT REPORT OF THE
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE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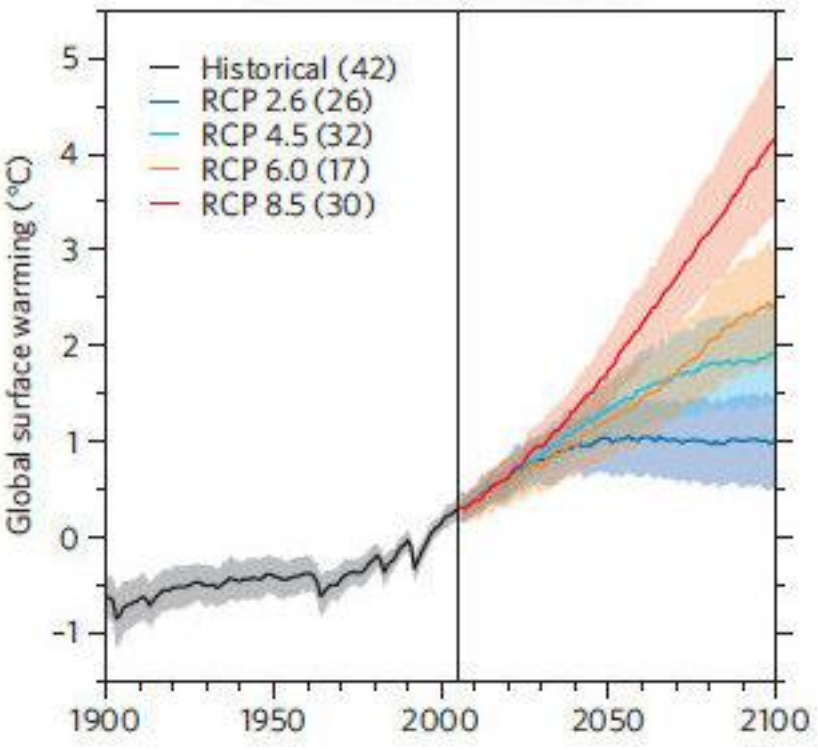
CLIMATE CHANGE 2014
Mitigation of Climate Change

AR5 RCPs



Scenarios

- **Representative concentration pathways (RCPs) are scenarios that include time series of emissions & concentrations of the full suite of GHGs and aerosols and chemically active gases, as well as land use/land cover. *Representative* signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics.**

- **4 RCPs used in WGII : RCP8.5 (high), RCP6.0 and RCP4.5 (intermediate), RCP2.6 (low) – named after level of radiative forcing reached or stabilized in 2100.**

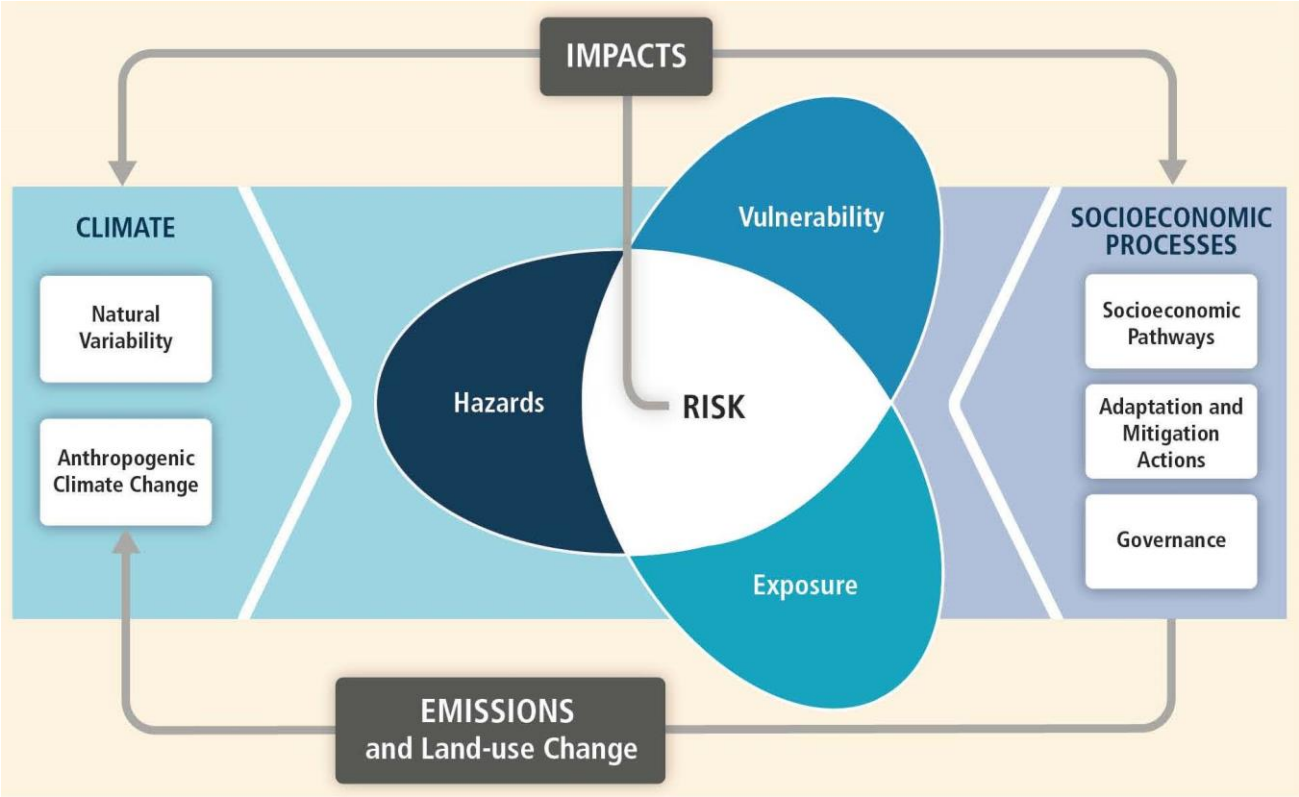
Managing risks

Risks

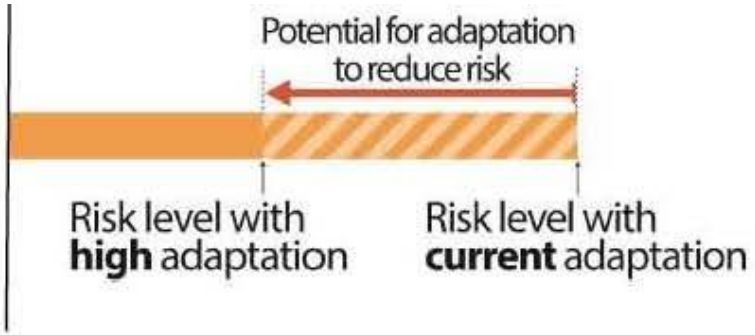
- **Risk : potential for consequences where something of human value (including humans themselves) is at stake and where the outcome is uncertain.**

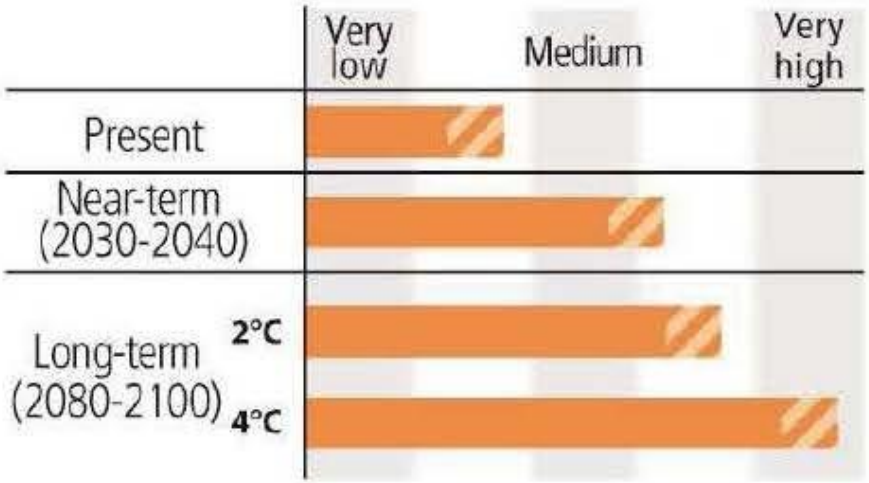
  Risk = hazard x vulnerability x exposure.

- **Risk management : Plans, actions, or policies implemented to reduce the likelihood &/or consequences of risks or to respond to consequences.**



Characterizing risks





AR6 & Special Reports

AR6 : 2021

- **Special Report on global warming of 1.5°C, scheduled for 2018.**
- **Special Report on climate change and oceans & the cryosphere, scheduled for 2019.**
- **Special Report on climate change, desertification, land degradation, sustainable land management, food security, & GHG fluxes in terrestrial ecosystems, where the scoping process may consider opportunities for both adaptation & mitigation, scheduled for 2019.**
- **Methodology Report to update & supplement the 2006 IPCC Guidelines for National Greenhouse Gas Inventories , scheduled for 2019.**

2. ASEAN

ASEAN and SE Asia

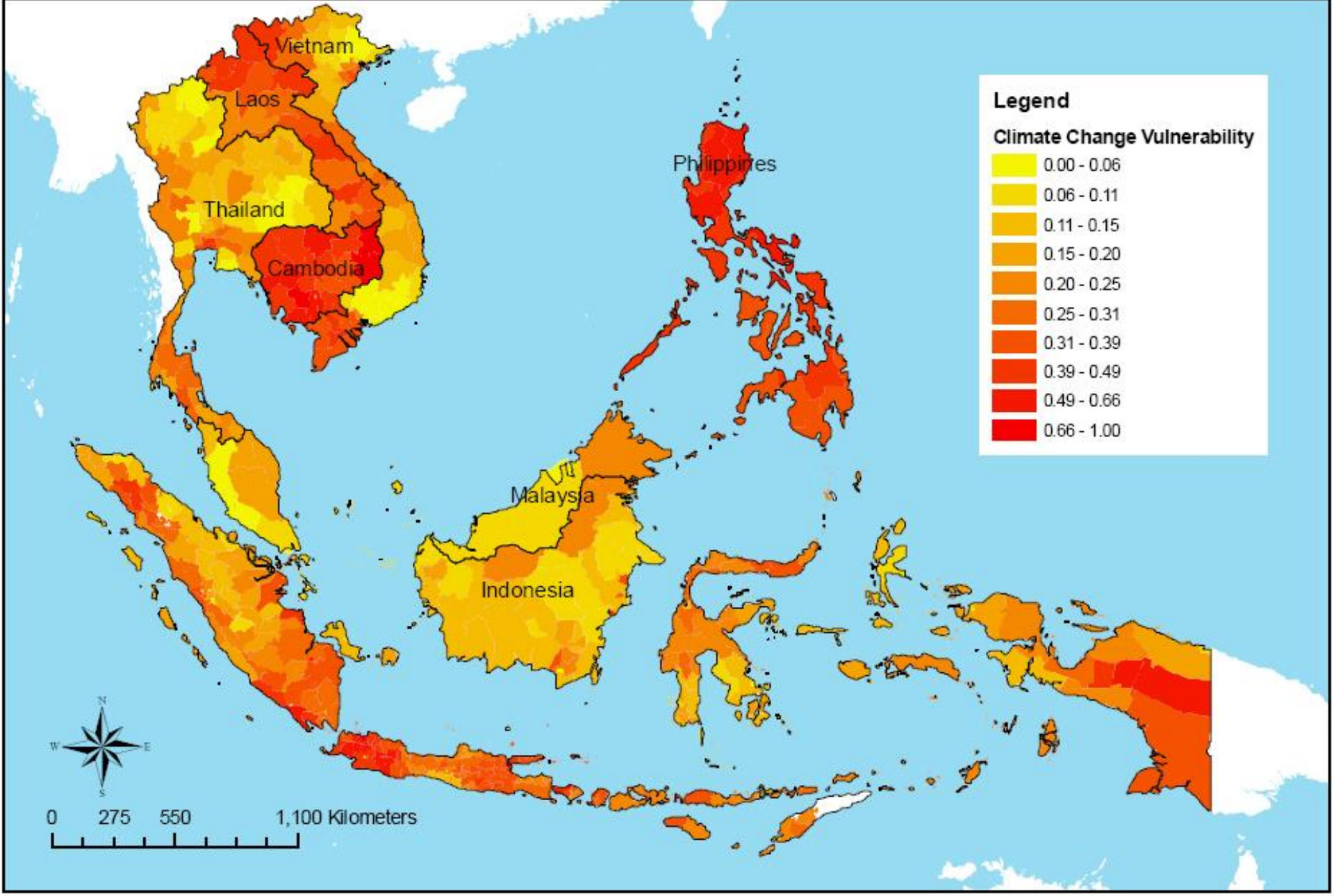
Vulnerability

Why vulnerable?

- **One of most vulnerable regions (others being S Asia & small island states). Due to long coastlines, high concentration of population & economic activity in coastal areas, & heavy reliance on agriculture, natural resources, & forestry.**

- **Already affected by climate change : increasing frequency & intensity of extreme weather events such as heat waves, droughts, floods & tropical cyclones in recent decades. Exacerbating water shortages, constraining agricultural production & threatening food security, causing forest fires & coastal degradation, & increasing health risks.**

- **Some highlights : impacts & adaptation options in four key areas - coasts, freshwater, food security, human settlements.**


Vietnam
Laos
Thailand
Cambodia
Philippines
Malaysia
Indonesia
Legend
Climate Change Vulnerability
0.00 - 0.06
0.06 - 0.11
0.11 - 0.15
0.15 - 0.20
0.20 - 0.25
0.25 - 0.31
0.31 - 0.39
0.39 - 0.49
0.49 - 0.66
0.66 - 1.00
N
W
E
S
0
275
550
1,100 Kilometers

(EEPSEA 2009)

3. Climate change

Regional features

- **Complex range of terrains & land–sea contrasts.**
- **With long coastlines therefore include some influence of the ocean.**
- **Several large-scale phenomena influence the climate of this region : monsoons, IOD, ENSO, TC, MJO.**
- **Climate variability & trends differ vastly across the region & between seasons. Strong seasonality in change is observed.**

Monsoons

- **East Asian monsoon : monsoonal flow that carries moist air from Indian Ocean & Pacific Ocean to East Asia, affecting most of SE Asia.**

- **Projected monsoon-related interannual rainfall variability will increase in future. Future increase in precipitation extremes related to monsoon is very likely.**

Indian Ocean Dipode (IOD)

- **IOD (Indian Niño) : an irregular oscillation of sea-surface temperatures in which western Indian Ocean becomes alternately warmer & then colder than eastern part of the ocean.**

- **Projected zonal (east–west) pattern of change : with reduced warming & decreased precipitation in the east, & increased warming & increased precipitation in the west, directly influencing SE Asian precipitation.**

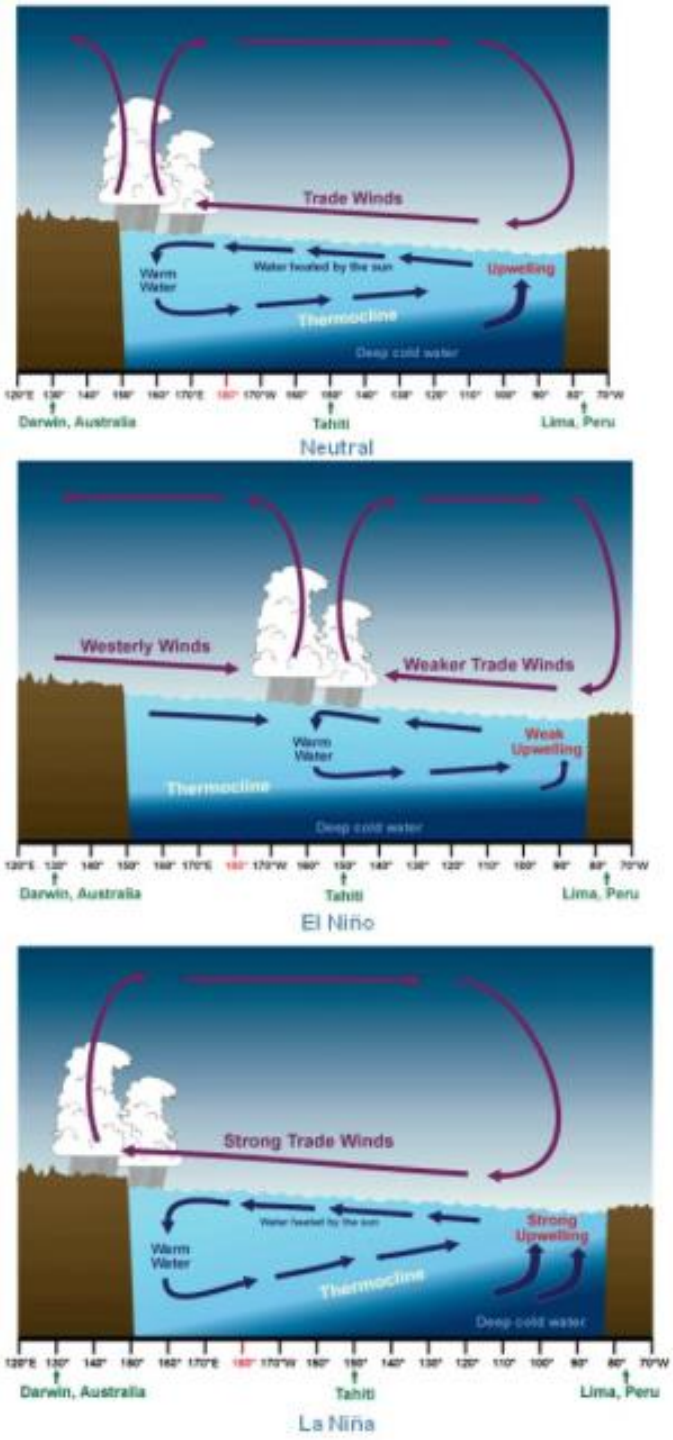
- **Impact more prominent in eastern Indonesia.**

El Niño Southern Oscillation (ENSO)

El Nino & La Nina

- **ENSO : irregularly periodic variation in winds & SST over tropical eastern Pacific Ocean, affecting much of tropics & subtropics.**

- **Warming phase is known as El Niño & the cooling phase as La Niña.**



ENSO on SE Asia (1)

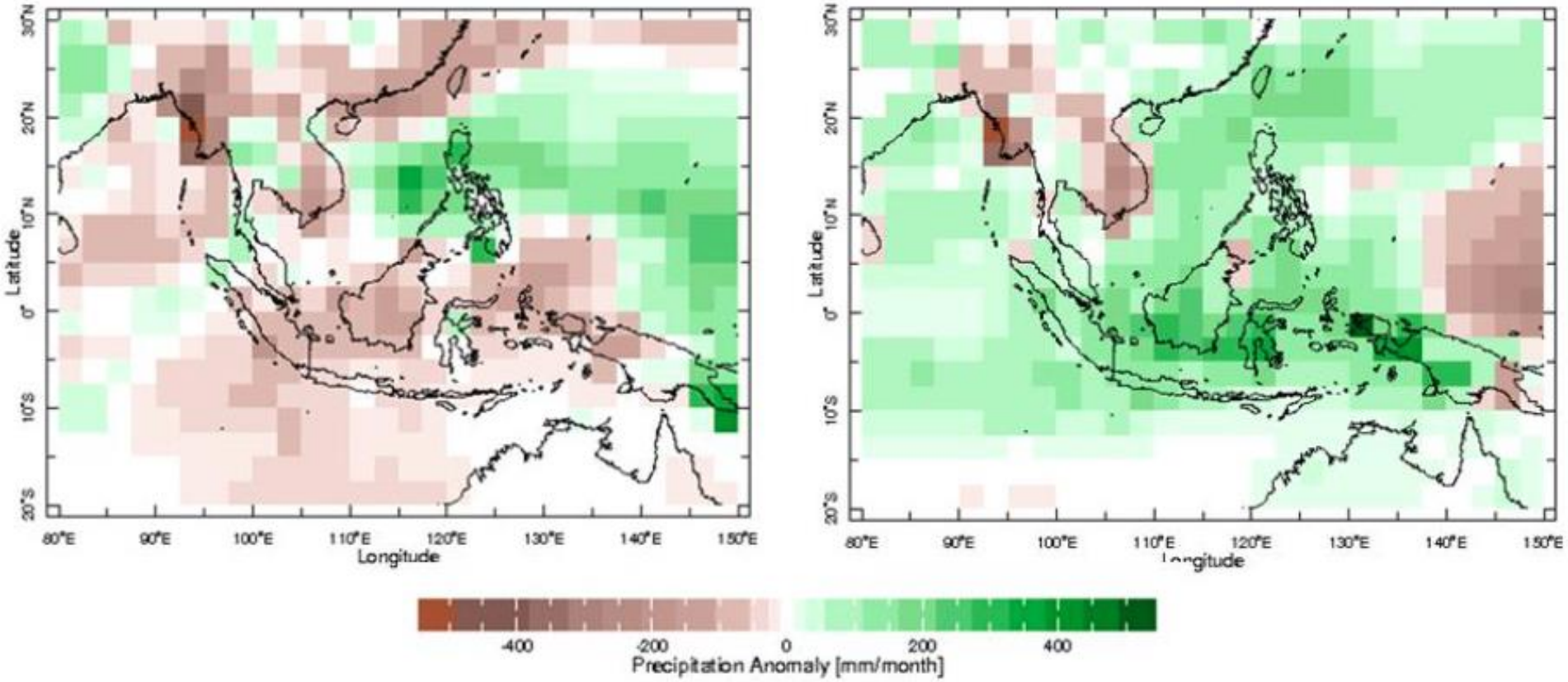
- **Warming of ocean surface or above-average sea surface temperatures in either central & eastern tropical Pacific Ocean. ENSO influence is predominant in East Malaysia & areas east of it. Reducing rainfall over Indonesia.**

- **Reduction in mean precipitation & enhanced warming if El Niño events become more frequent &/or intense.**

- **Projected dominant mode of interannual variability in the future; however, any specific projected change in its variability in the 21st century remains low.**

ENSO in SE Asia (2)

- Correlation between El Niño/La Niña & its associated weather impacts on SE Asia differ from one place to another & for different seasons.
- El Nino brings drier weather & increases risk of forest fires and smoke haze. La Niña brings higher than normal rainfall which may result in increased occurrence of floods.



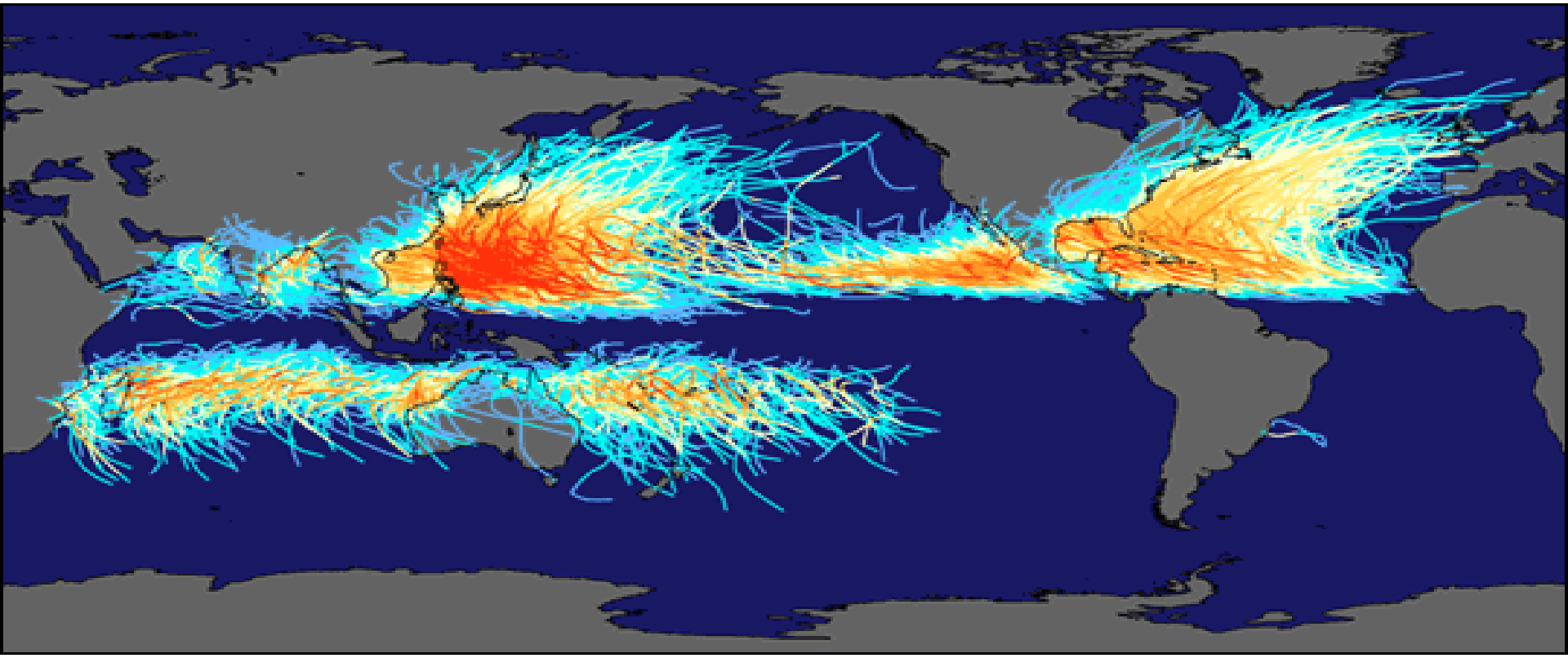
Tropical cyclones

Typhoons/cyclones/hurricanes

- **Rapidly rotating storm system. Increasing frequency of extreme events reported in northern parts of SE Asia, decreasing trends reported in Myanmar.**

- **Projected low confidence in region-specific projections of frequency & intensity. Projected increase in extreme precipitation near centres of tropical cyclones.**

Tropical cyclones (typhoons)

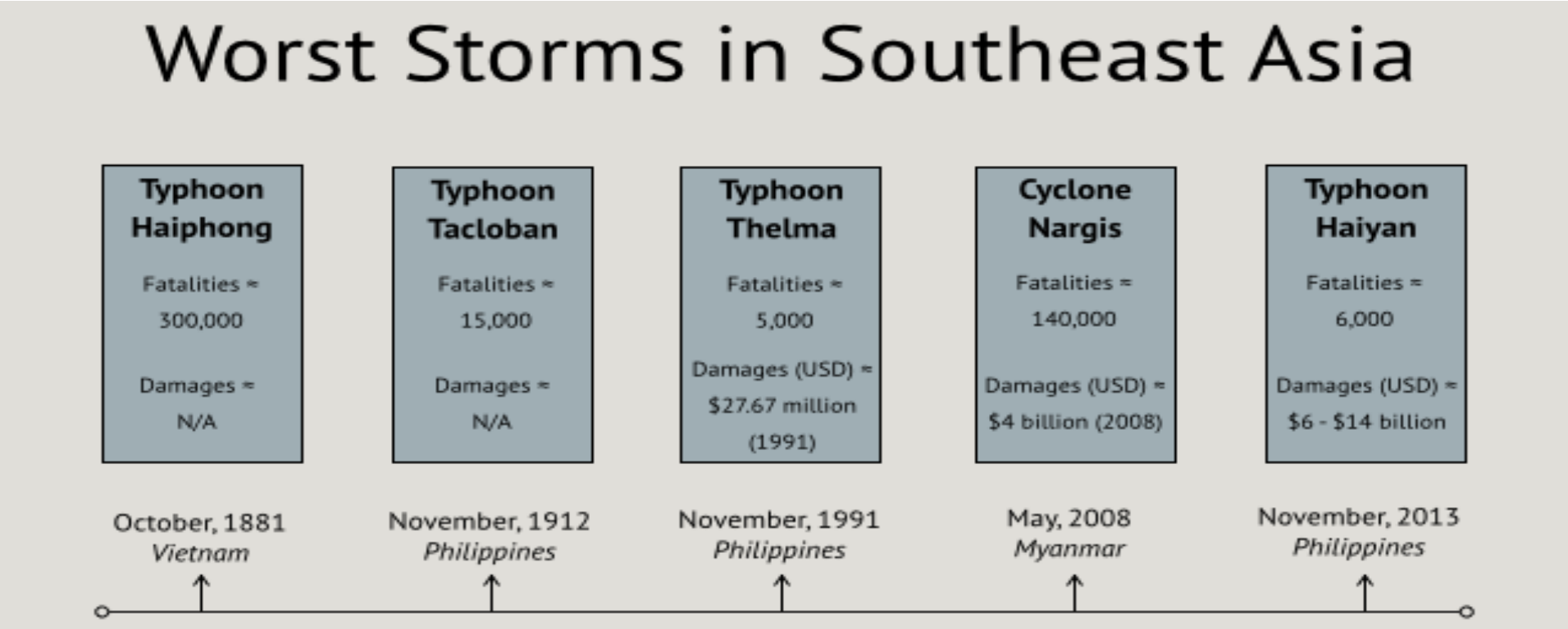


(Rohde)

Examples

- **Tropical cyclones (typhoons) : (frequency & intensity of cyclones not fully known); storm surge sensitive to tropical cyclones; precipitation be more extensive where tropical cyclones make landfall.**

- **Monsoons : increases in precipitation extremes.**

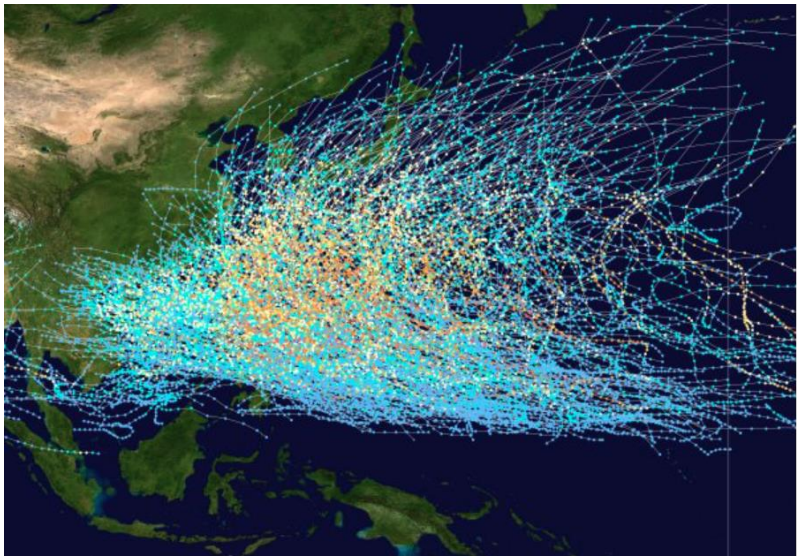


ASEAN - Post Nargis Knowledge Management Portal
Weather Underground

Update on tropical cyclones

Update

- **Category 4 and 5 storms striking southeast Asia has doubled since 1977.**
- **Overall destructive power of storms striking this region has increased by nearly 50%over the same period.**
- **Increase in powerful storms has been caused by ocean warming related to climate change.**



Madden-Julian Oscillation (MJO)

- **Largest element of the intraseasonal (30- to 90-day) variability in the tropical atmosphere. Unlike a standing pattern like the ENSO, MJO is a traveling pattern that propagates eastward. Associated with enhanced rainfall in Indonesia during northern winter & SE Asia during northern summer.**

- **Due to poor ability of models to simulate it & its sensitivity to ocean warming patterns, future projections of regional climate extremes in SE Asia are therefore highly uncertain when associated with the MJO.**

Observed climate change

Observed

- **Temperature : increasing at a rate of 0.14°C to 0.20°C per decade since 1960s, coupled with rising number of hot days & warm nights, & decline in cooler weather.**

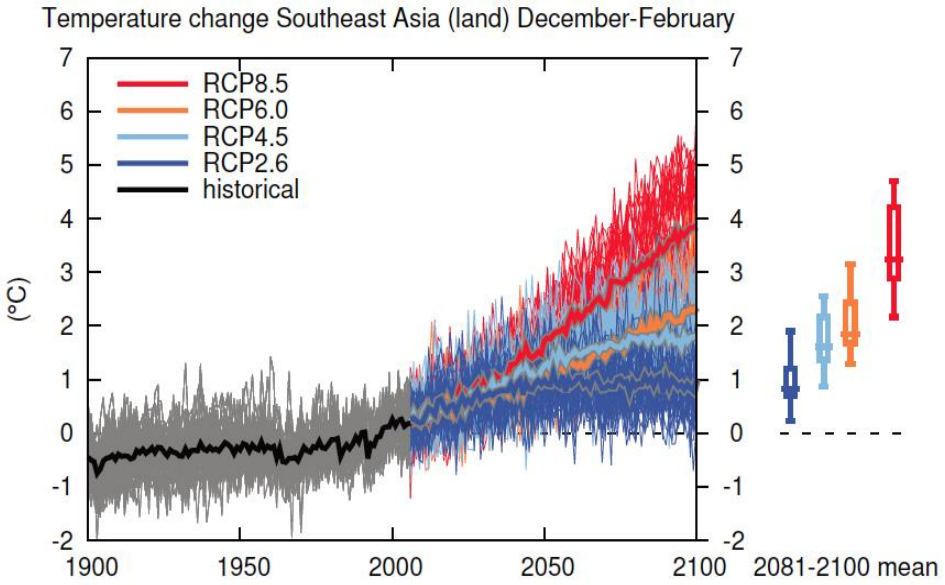
- **Rainfall : annual total wet-day rainfall increased by 22 mm per decade, while rainfall from extreme rain days increased by 10 mm per decade, but climate variability & trends differ vastly across the region & between seasons.**

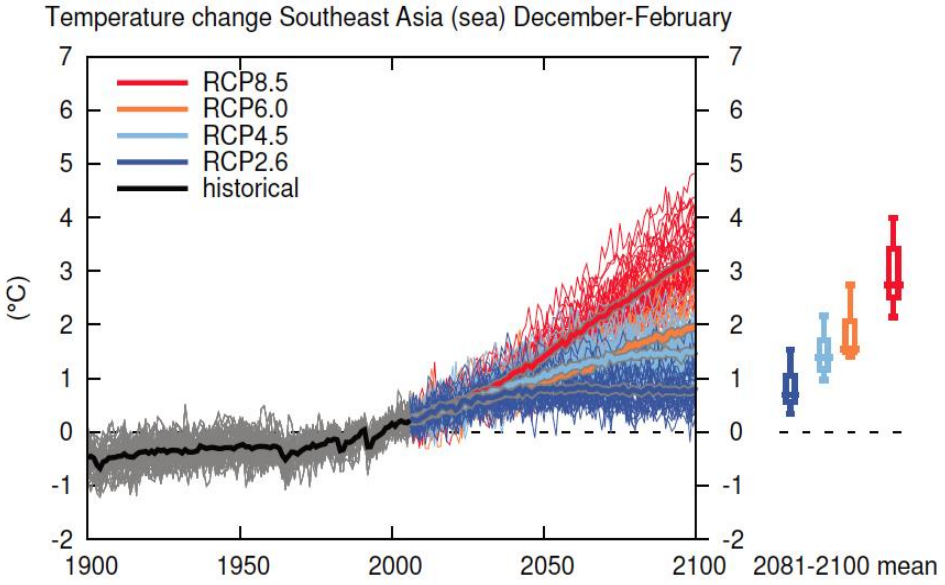
- **While an increasing frequency of extreme events has been reported in the northern parts of SE Asia, decreasing trends in such events are reported in Myanmar.**

Temperature change

Predicted : temperature

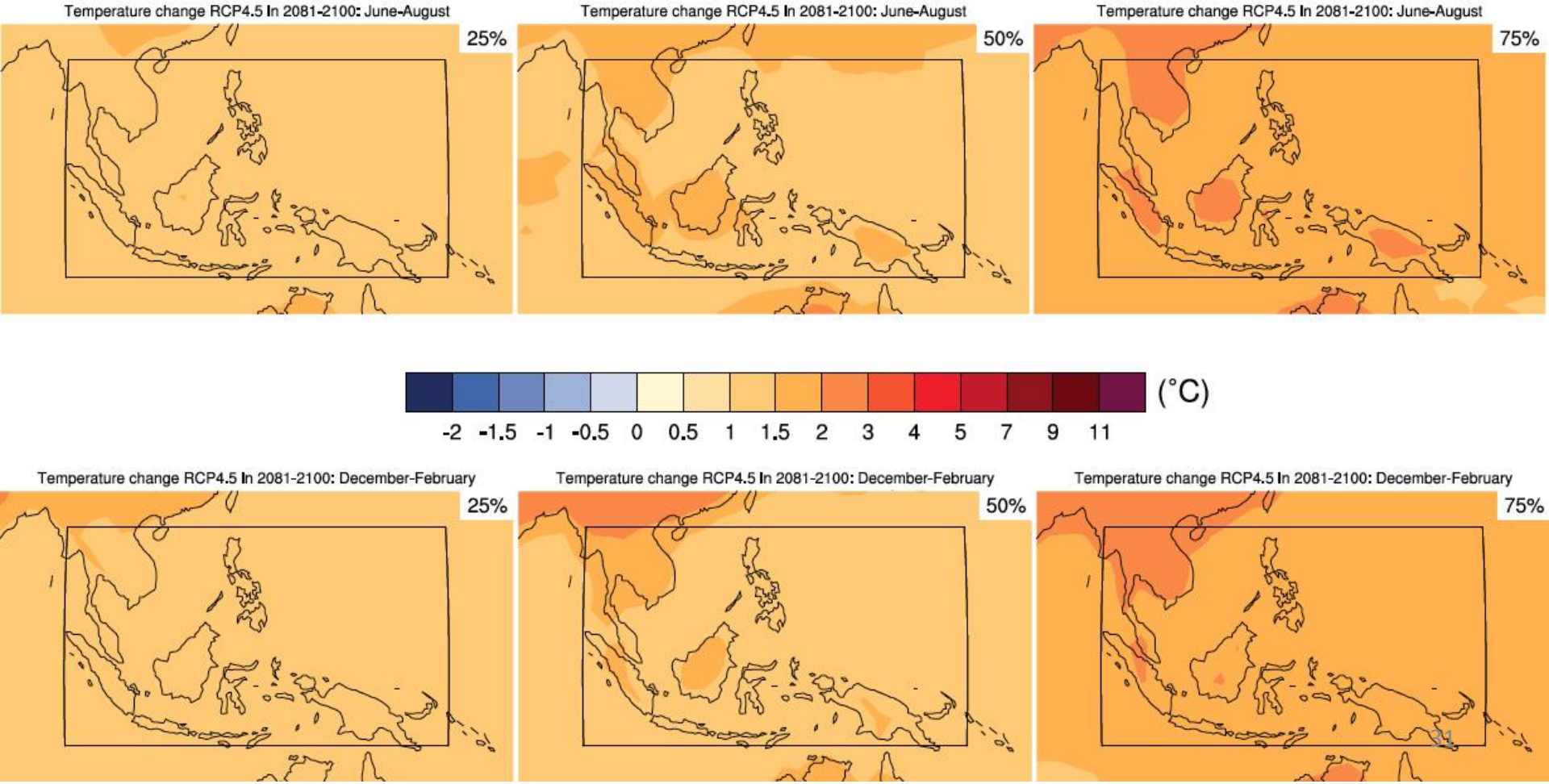
- **The median increase in temperature over land ranges from 0.8°C in RCP2.6 to 3.2°C in RCP8.5 by the end of this century (2081–2100).**





Temp. mean changes for 2081-2100

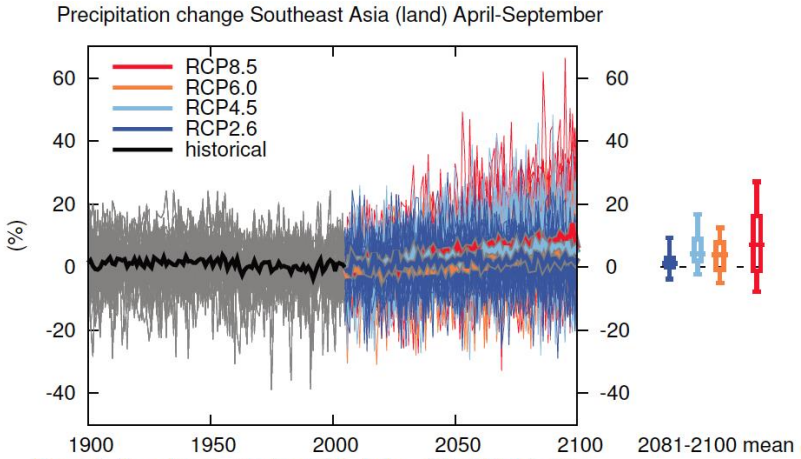
- **Warming** is very likely to continue with substantial sub-regional variations.

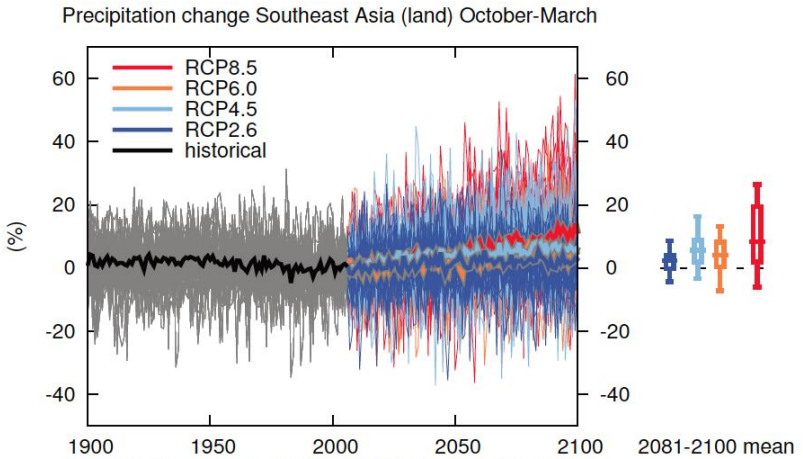


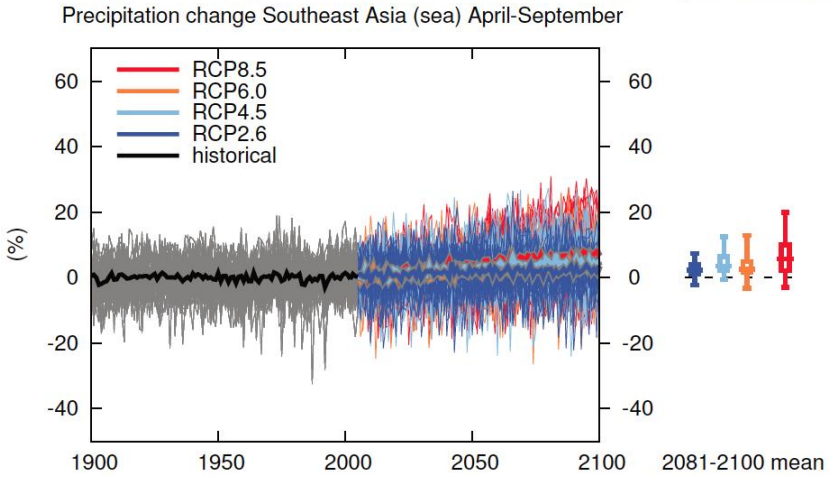
Precipitation change

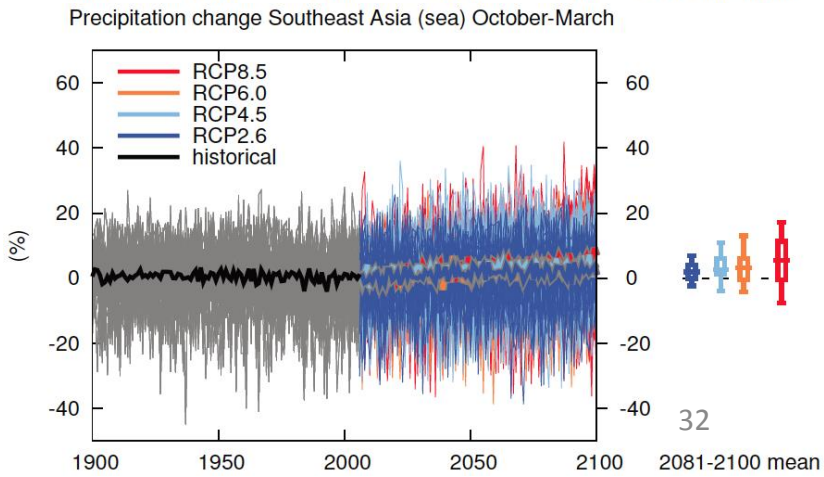
Predicted : precipitation

- **Moderate increase in precipitation is projected : 1% in RCP2.6 increasing to 8% in RCP8.5 by 2100.**



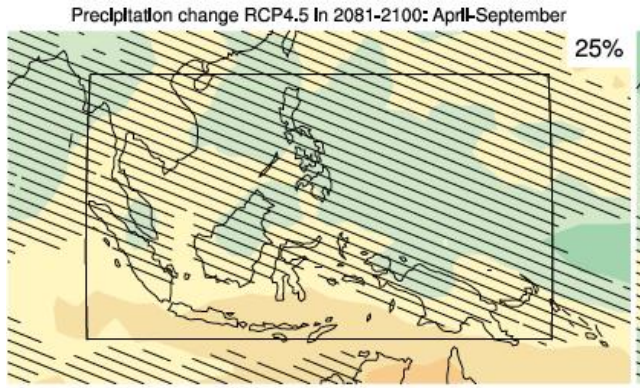


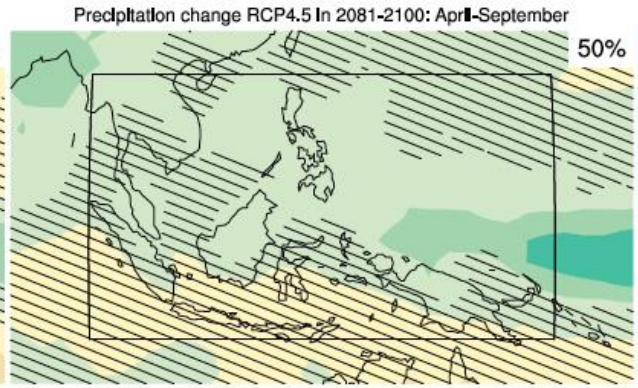


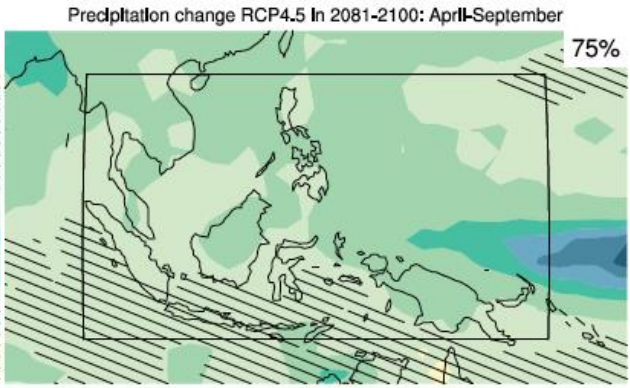


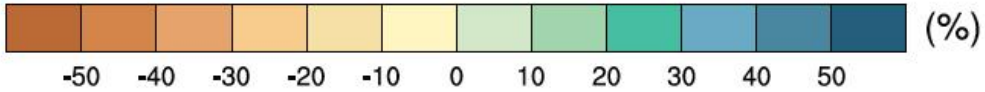
Precip. mean changes for 2081-2100

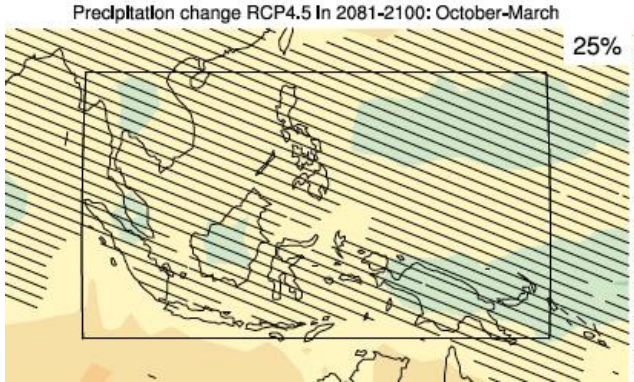
- Moderate increase in rainfall, except on Indonesian islands neighbouring southeast Indian Ocean.
- On islands neighbouring the southeast tropical Indian Ocean, rainfall is projected to decrease during July to November (the IOD prevalent season), consistent with a slower oceanic warming in the east than in the west tropical Indian Ocean despite little change in IOD.
- Strong regional variations expected because of terrain.

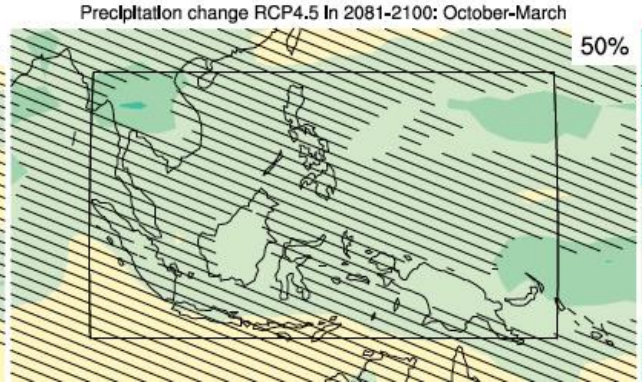


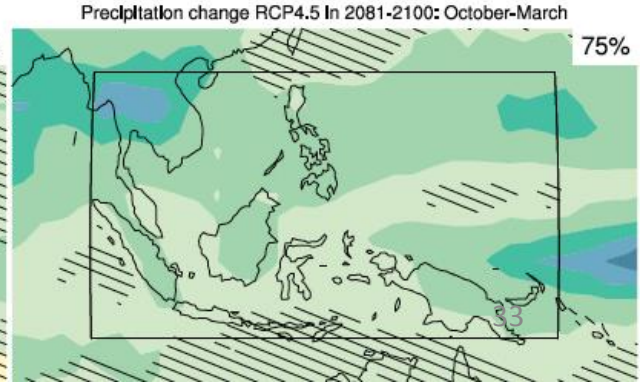












Summary - climate change

Region/ region code	Trends in daytime temperature extremes (frequency of hot and cool days)		Trends in heavy precipitation (rain, snow)		Trends in dryness and drought	
	Observed	Projected	Observed	Projected	Observed	Projected
Southeast Asia SEA, 24	Increases in hot days (decreases in cool days) for northern areas[a] Insufficient evidence for Malay Archipelago[a]	*Likely* increase in hot days (decrease in cool days)[b]	Spatially varying trends, partial lack of evidence[a]	Increases in most metrics over most (especially non-continental) regions. One metric shows inconsistent signals of change.[b]	Spatially varying trends[a]	Inconsistent signal of change[b]

(TS 2014)

Question 1

- **What is the extent of knowledge of climate change in your country?**

4. Coasts

Projected MSLR

Emission scenario	Representative Concentration Pathway (RCP)	2100 CO_2 concentration (ppm)	Mean sea level rise (m)	
			2046–2065	2100
Low	2.6	421	0.24 [0.17–0.32]	0.44 [0.28–0.61]
Medium low	4.5	538	0.26 [0.19–0.33]	0.53 [0.36–0.71]
Medium high	6.0	670	0.25 [0.18–0.32]	0.55 [0.38–0.73]
High	8.5	936	0.29 [0.22–0.38]	0.74 [0.52–0.98]

Emission scenario	Mean sea level rise (m)		
	2200	2300	2500
Low	0.35–0.72	0.41–0.85	0.50–1.02
Medium	0.26–1.09	0.27–1.51	0.18–2.32
High	0.58–2.03	0.92–3.59	1.51–6.63

Coastal systems

- **Low-lying coasts support mangrove forests, most of world peat swamp forests.**
- **40% of world's coral reefs in Asia, mostly in SE Asia.**
- **Also widespread seagrass beds.**

(NASA/USGS)

Coastal risks

(IPCC 2014)

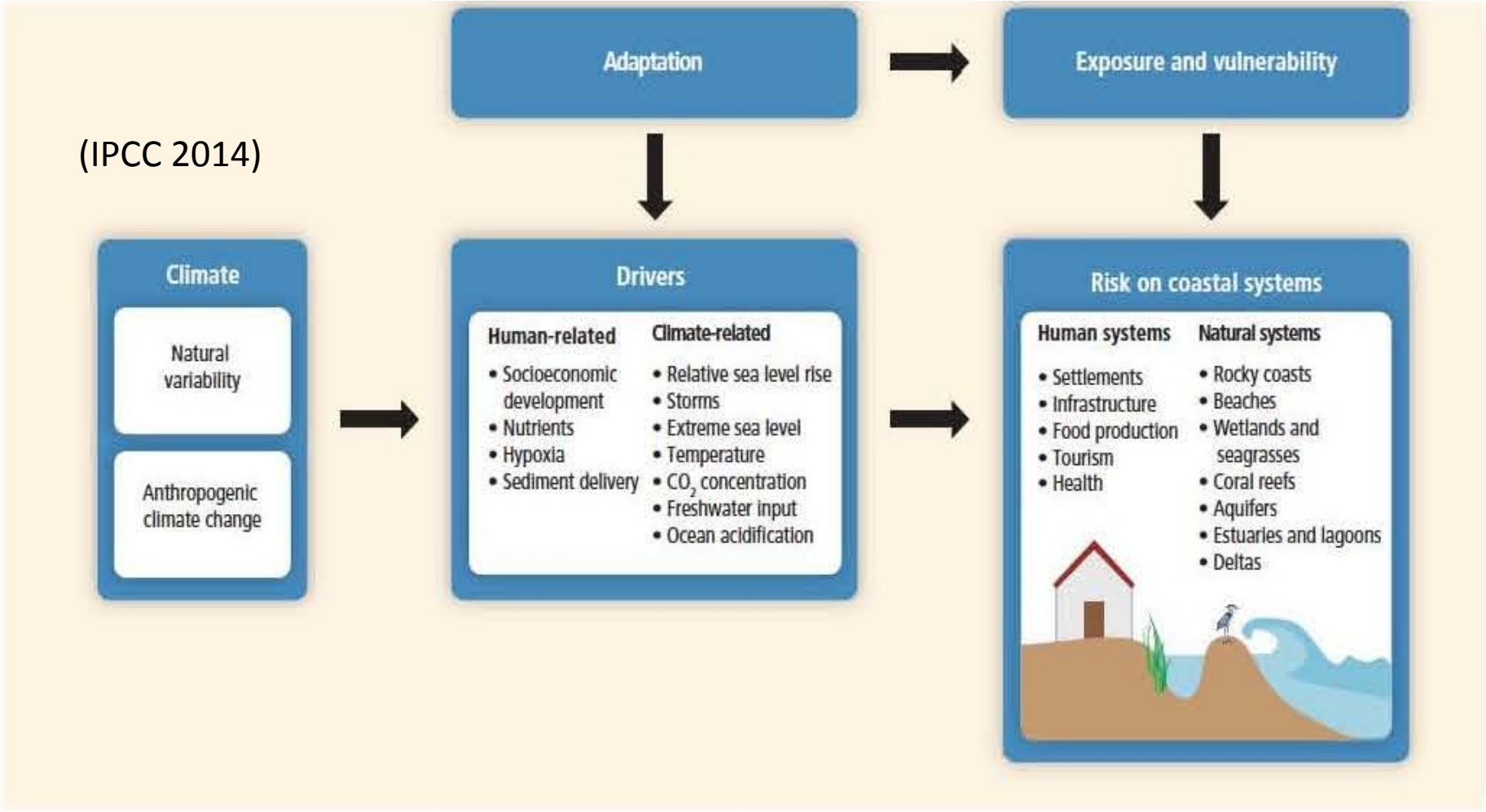


Figure 5-1 | Climate, just as anthropogenic or natural variability, affects both climate and human related drivers. Risk on coastal systems is the outcome of integrating drivers' associated hazards, exposure, and vulnerability. Adaptation options can be implemented either to modify the hazards or exposure and vulnerability, or both.

Projected impacts on coasts

Projected impacts

- **Increasing SST & ocean acidification : declines in coral-dominated reefs & other calcified marine organisms. On rocky shores warming & acidification are expected to lead to range shifts & changes in biodiversity.**

- **SLR : increase coastal flooding, coastal erosion & saltwater intrusion; mangroves, salt marshes & seagrass beds decline unless they receive sufficient fresh sediments to keep pace of SLR or retreat inland.**

- **Cyclone intensification with SLR : increase coastal flooding. In 2013, 176 million people in (Asian) region were affected by natural disasters such as flooding & cyclones, with 3.5 million displaced due to climate-related catastrophes.**

Acidification and coral reefs

- **Continuation of current trends in sea surface temperatures & ocean acidification would result in large declines in coral-dominated reefs by mid-century.**

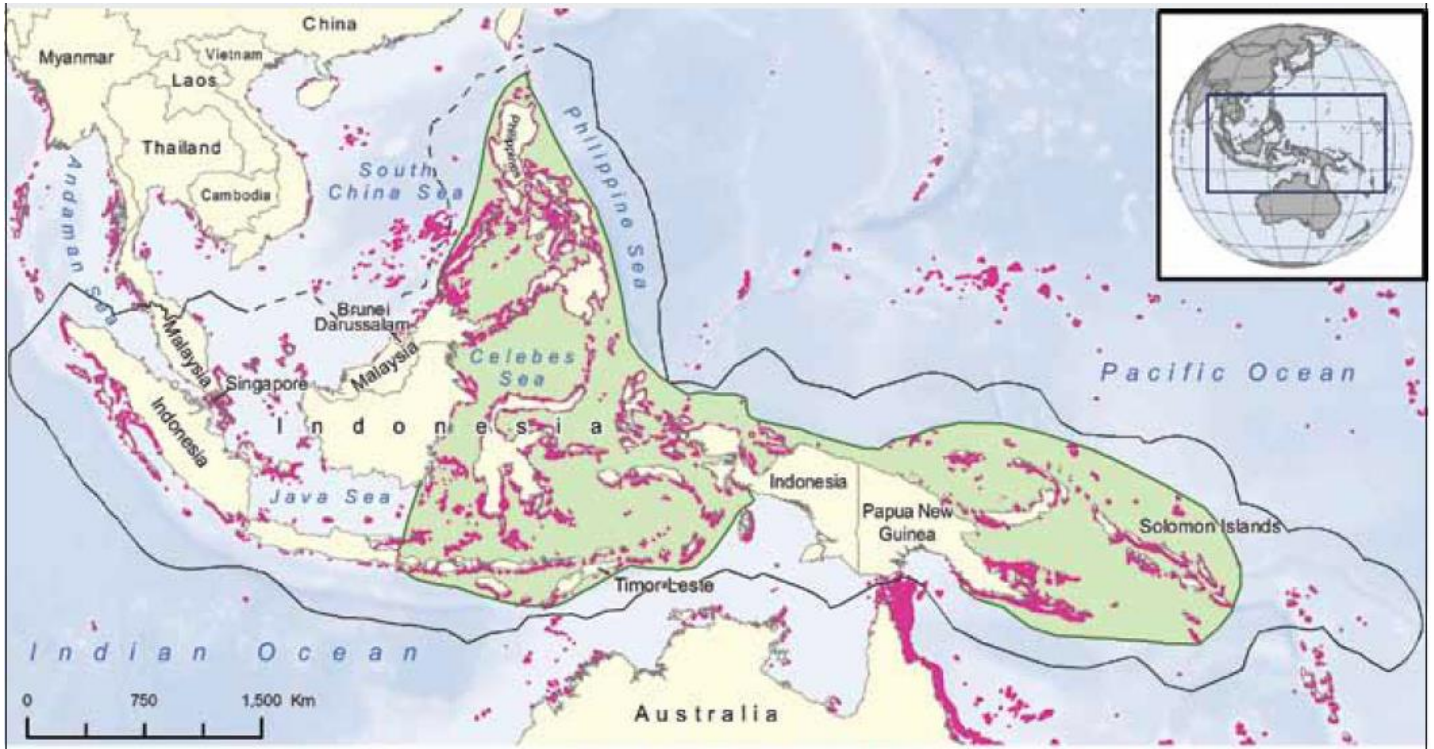
- **Coral reefs will be most vulnerable marine ecosystem with little scope for adaptation. Warming & acidification will lead to coral bleaching, mortality & decreased constructional ability. [Acidification highlighted in AR5 than in AR4, due to more information & two ocean chapters in AR5]**

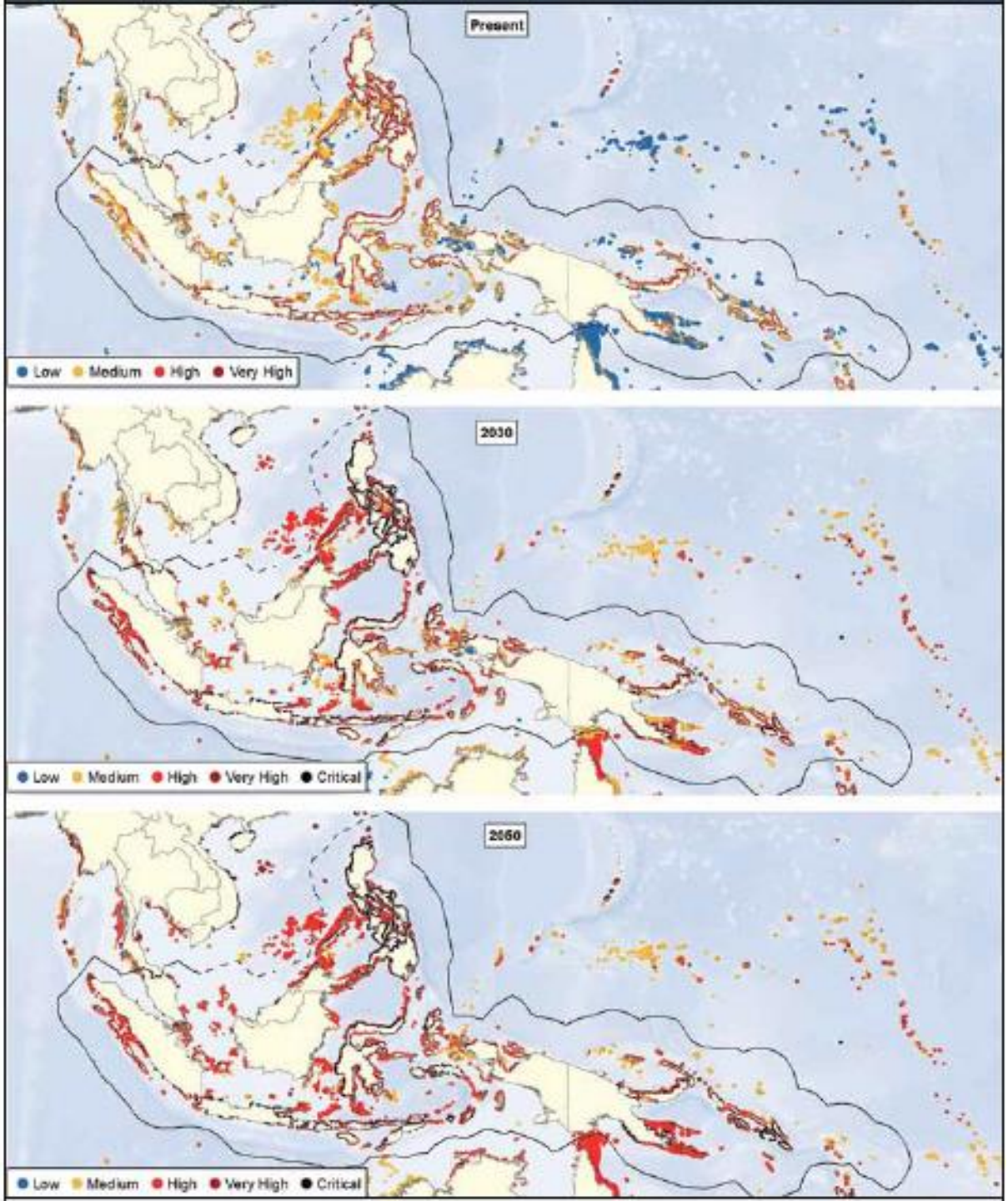
- **Acidification also expected to have negative impacts on other calcified marine organisms with large & uncertain regional & local variations.**

Coral Reef Triangle

Coral Reef Triangle

- **Contains nearly 73,000 sq km of coral reefs (29% of global total).**
- **Spans parts of 6 countries: Indonesia, Malaysia, PNG, Philippines, Solomon Islands, & Timor-Leste.**
- **Recent thermal stress & coral bleaching combined with local threats (overfishing, pollution, coastal developments).**





Present : high & very high

2030s : 80% high, very high, & critical

2050 : 90% high, very high, & critical

(Burke et al 2012)

SLR

Projected impacts of SLR

- **Future rates of SLR are expected to exceed those of recent decades, increasing coastal flooding, erosion, & saltwater intrusion into surface & groundwater.**

- **In the absence of other impacts, coral reefs may grow fast enough to keep up with rising sea levels; but beaches may erode & mangroves, salt marshes, & seagrass beds will decline, unless they receive sufficient fresh sediment to keep pace or they can move inland**

- **Coastal freshwater wetlands may be vulnerable to saltwater intrusion with rising sea levels, but in most river deltas local subsidence for nonclimatic reasons will be more important.**

- **Current trends in cyclone frequency & intensity are unclear, but combination of cyclone intensification & SLR could increase coastal flooding.**

RSLR

Relative SLR (country)

- **RSLR at local scale can be much larger than projected GMSLR.**
- **Non-climate change local processes include subsidence, glacial isostatic adjustment, sediment transport, coastal development.**
- **Changes in storms & associated storm surges may further contribute to sea level extremes.**
- **Under present levels of global warming, already committed to higher future SLR above current levels.**

Non-climate factors

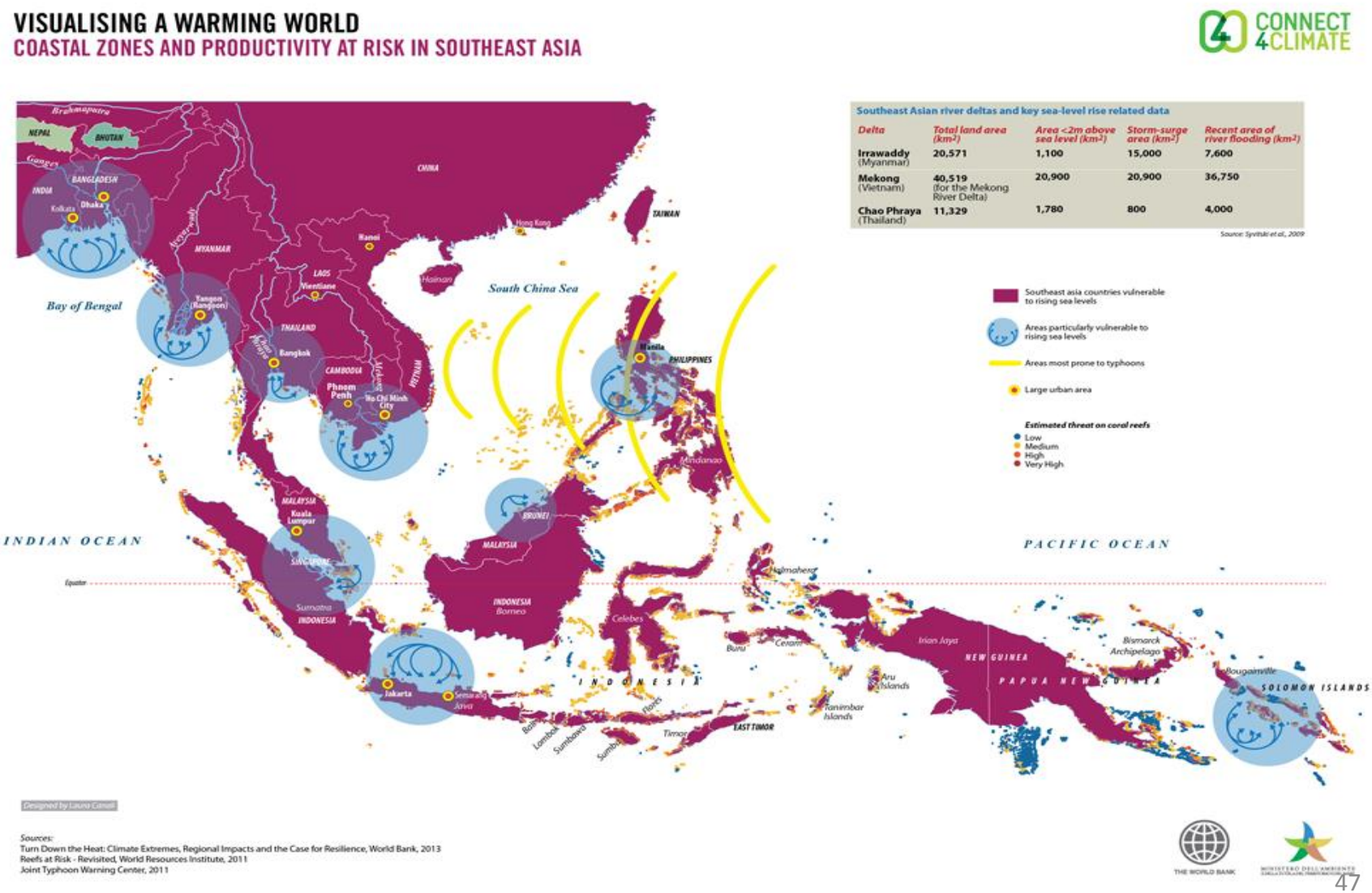
Non-climate factors

- **Increase significantly in future due to population growth, economic development, & urbanization.**

- **Humans have been primary drivers of change in coastal aquifers, lagoons, estuaries, deltas & wetlands.**

- **Further exacerbation on coastal ecosystems from excess input, changes in runoff & reduced sediment delivery.**

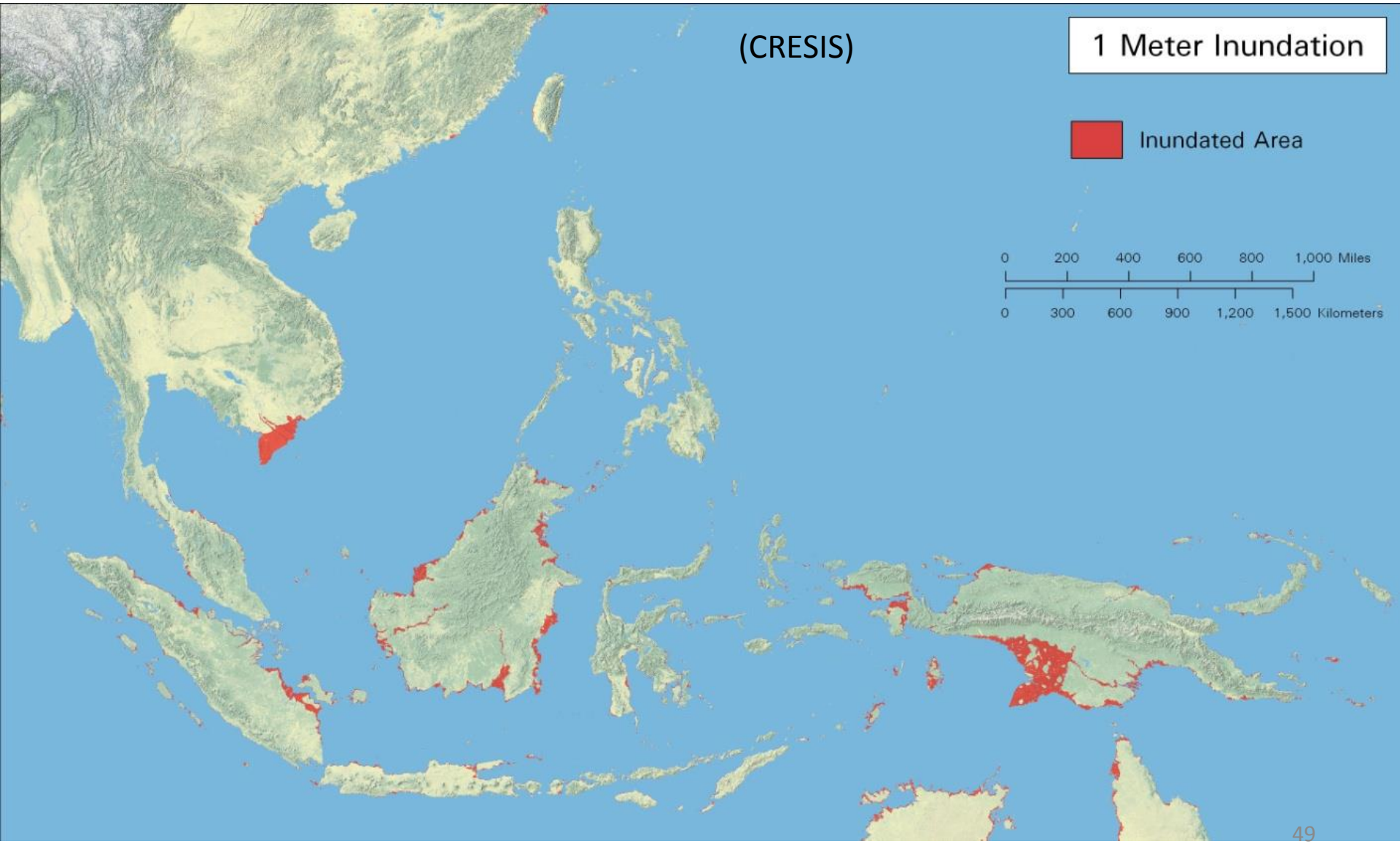
Coastal zones at risk



SLR vulnerability

(Jones et al 2012)

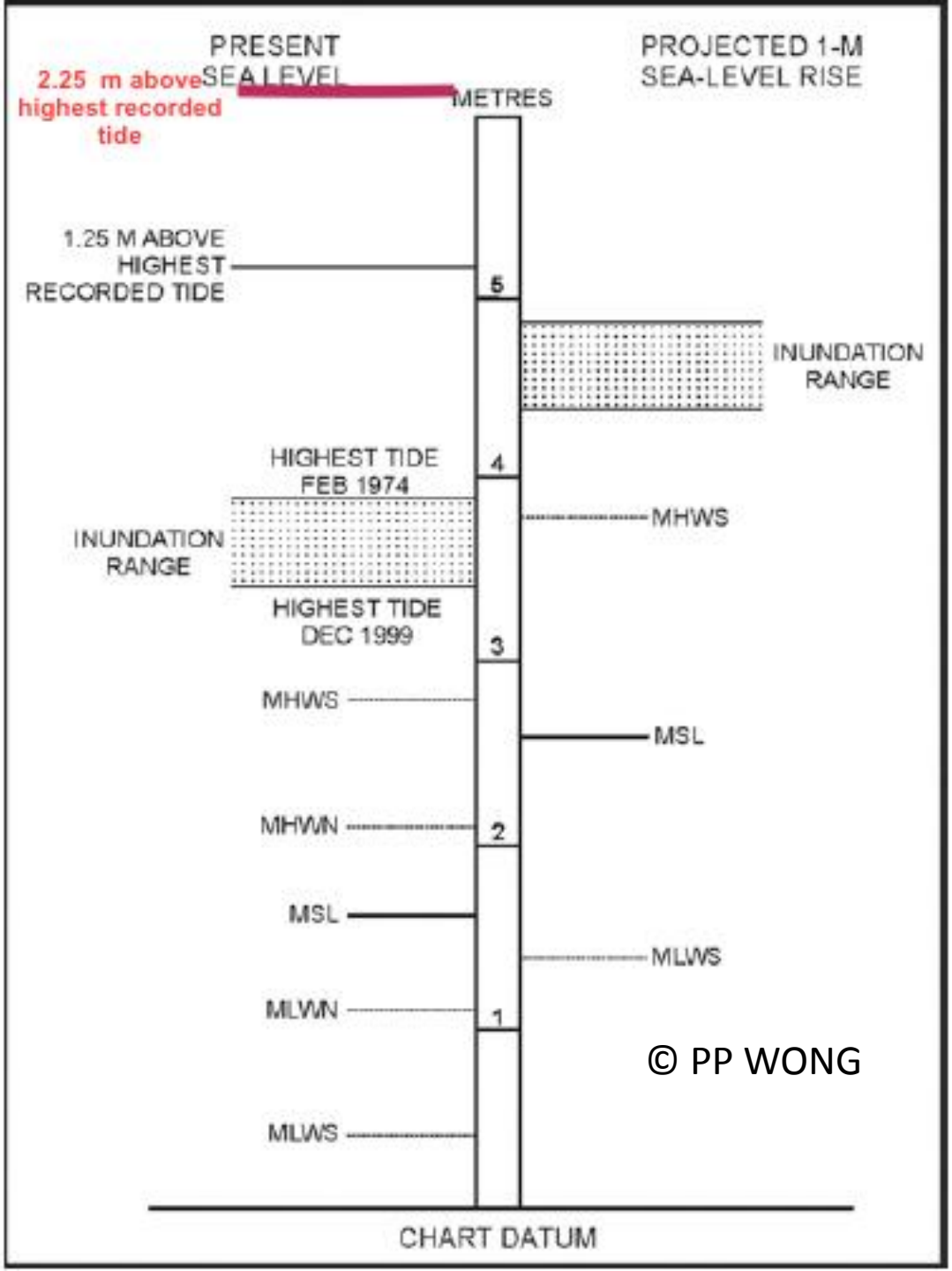
SLR – 1 m SLR


(CRESIS)
1 Meter Inundation
Inundated Area
0 200 400 600 800 1,000 Miles
0 300 600 900 1,200 1,500 Kilometers

Extreme spring tides

- ***Jour Southeast Asian Earth Sciences*, 1992, 7 : 65-70.**

Feb 1974 (3.9 m) **Dec 1999 (>3.4 m)** **Dec 2011 (>3.4)**



1-m SLR & extreme spring tides

‘King Tides’ Watch
‘King Tides’ Witness

5. Freshwater

Freshwater resources

- **Importance : massive population & heavy dependence of agricultural sector on precipitation, river runoff, & groundwater.**

- **Non-climate drivers : soaring populations, increasing per-capita domestic use, due to urbanization & thriving economic growth, & increasing use of irrigation.**

- **Water scarcity is expected to be a big challenge in many regions because of increasing water demand from population growth & consumption per capita with higher standards of living.**

Aquifers

Aquifers

- **Groundwater sources, which are affordable means of high-quality water supply in cities of developing countries, are threatened due to over-withdrawals.**

- **Aquifer levels have fallen by 20 to 50 m in cities such as Bangkok & Manila. Drop in groundwater levels often results in land subsidence, which can enhance hazard exposure due to coastal inundation & SLR especially in settlements near the coast, & deterioration of groundwater quality.**

Projected impacts

Projected

- **Future water availability differs substantially among river basins & seasons.**

- **Low confidence in projections of specifically how climate change will impact future precipitation on sub-regional scale, & in projections of how climate change might impact availability of water resources.**

- **Future projections suggest a decrease in river runoff in January in Chao Phraya River basin, Thailand.**

6. Food security

Key drivers

- **Food production & food security are most vulnerable to rising air temperatures. Warmer temperatures could depress yields of major crops such as rice.**

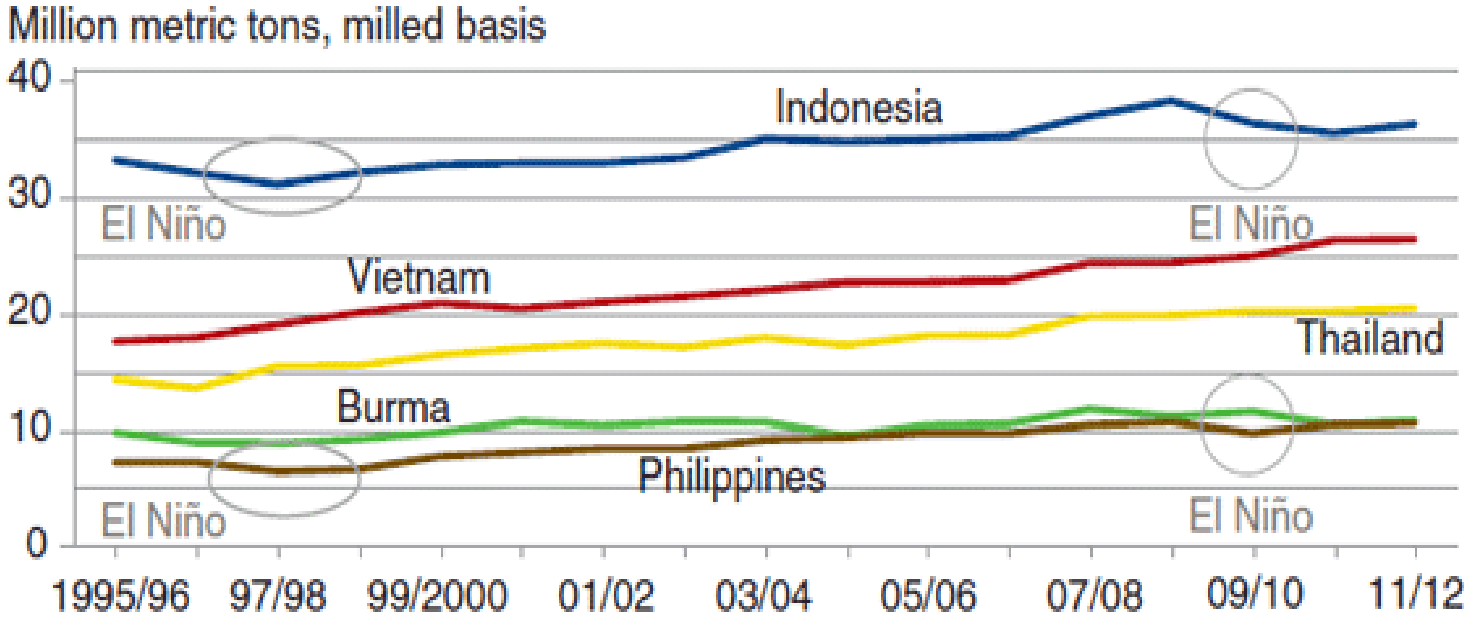
- **SLR will be a key issue for many coastal areas as rich agricultural lands may be submerged & taken out of production.**

Agriculture - temperature

- **Current temperatures : already approaching critical levels during susceptible stages of the rice plant in Myanmar/Thailand/Laos/Cambodia (March-June), Vietnam (April/August), Philippines (April/June), Indonesia (August).**

- **With rising temperatures, the process of rice development accelerates & reduces the duration for growth.**

(USDA)



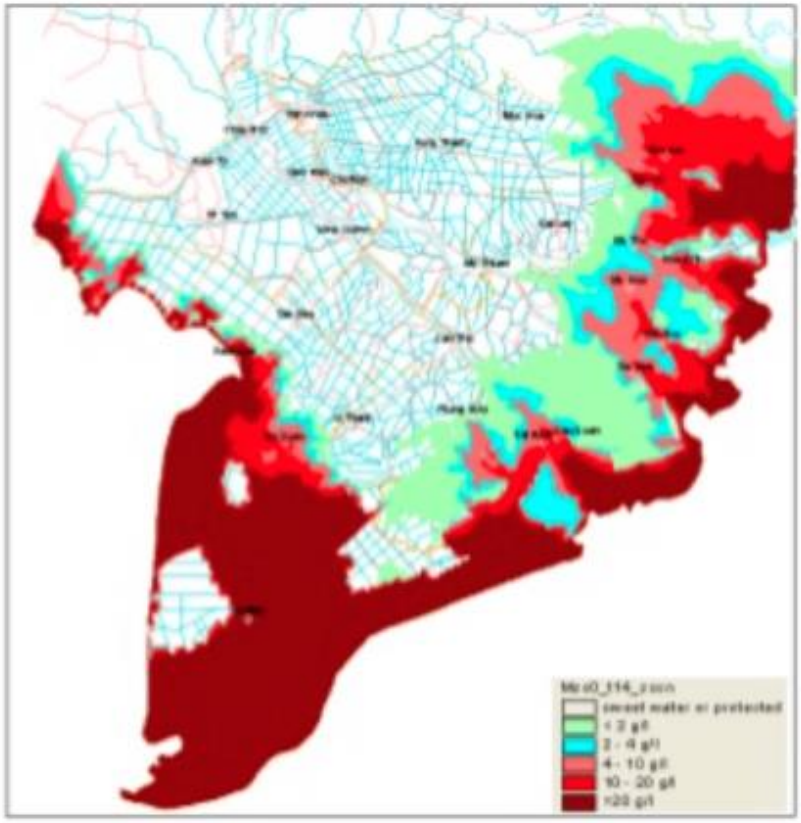
Agriculture - SLR

Agriculture & SLR

- **SLR : key issue for many coastal areas as rich agricultural lands may be submerged.**

- **Threatens coastal & deltaic rice production areas particularly in Mekong River Delta. E.g. about 7% of Vietnam's agriculture land may be submerged, decrease in Myanmar's rice yield due salt water intrusion.**

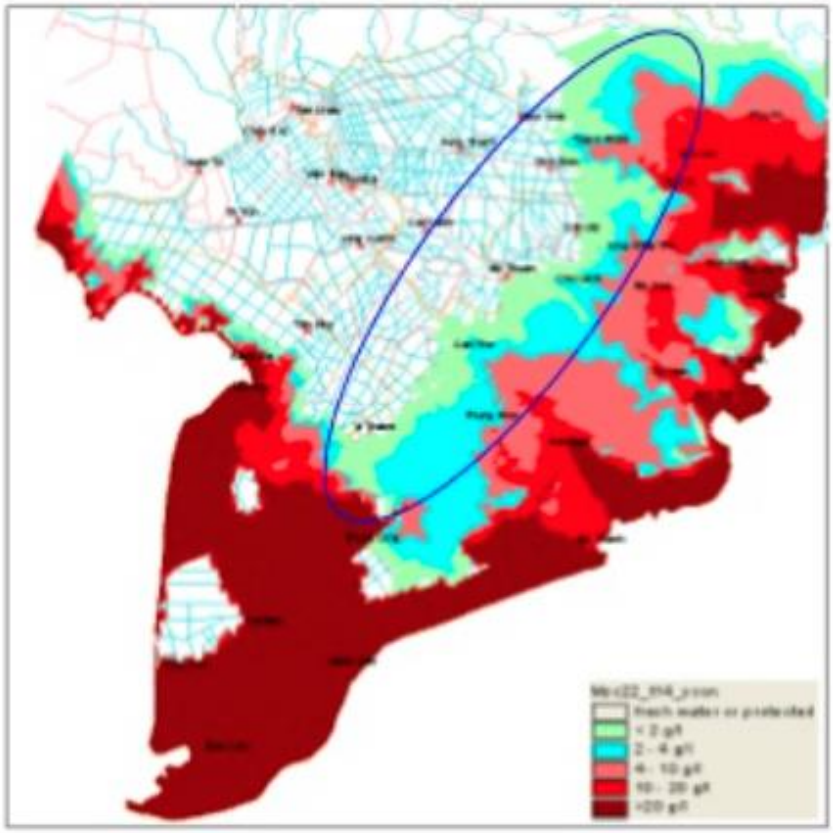
Mekong Delta – 0.3 m SLR on rice



SLR by 30 cm:

50,000 ha affected (of 1.8m ha)

•120,000 tonnes less rice (23m tonnes)



SLR 30 cm + dams + drought

500,000 ha affected

• 1,000,000 tonnes less rice

(MRFI 2015)

Fisheries

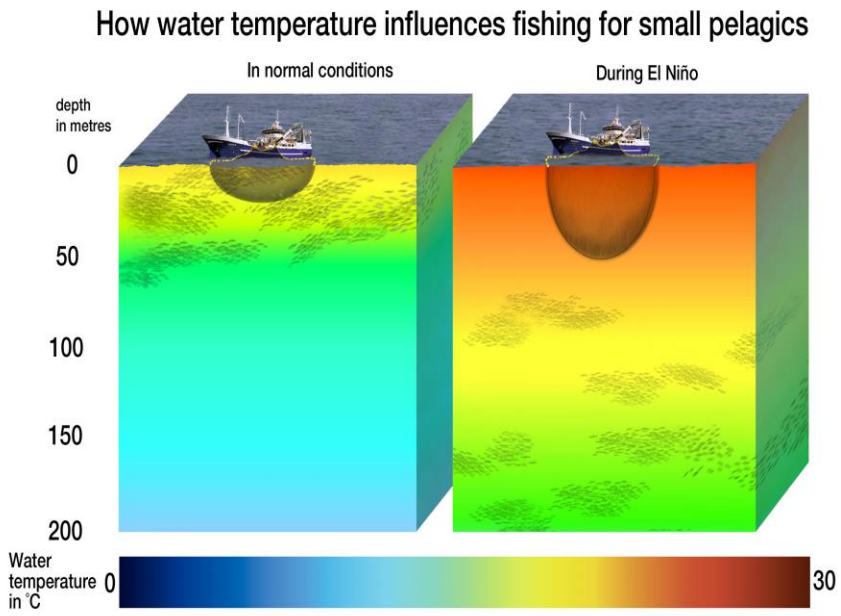
Fisheries

- **Concern centered on rising water temperatures & potential impacts of climate change on flow regimes, which affect the reproduction of many fish species.**

- **Decline in marine productivity in part due to vulnerability of coral reefs to both warming & ocean acidification.**

- **Climate change may lead to massive redistribution of fisheries catch potential with large declines in the tropics, particularly Indonesia.**

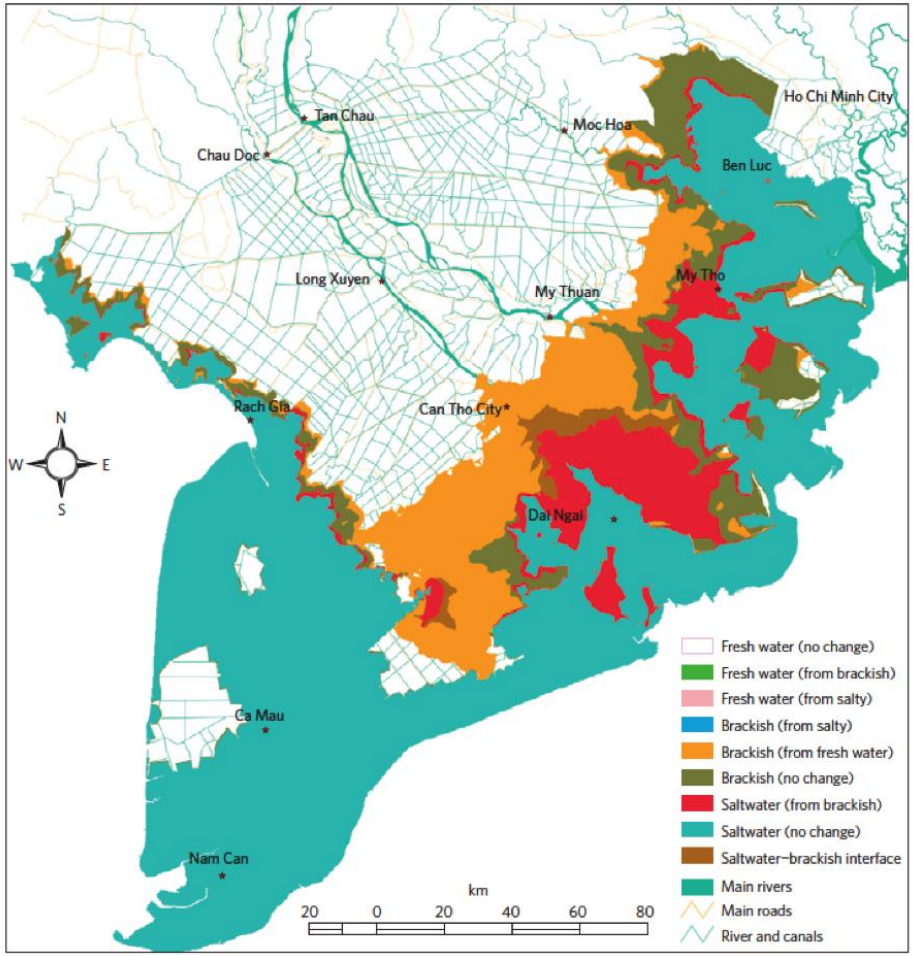
- **Destructive fisheries : human factor.**



Deltas – capture fisheries & aquaculture

- **Lower Mekong River basin** supports largest freshwater capture fishery in the world & would be negatively impacted.

- **Sea level rise** is expected to impact both capture fisheries & aquaculture production in river deltas : increasing salinity.

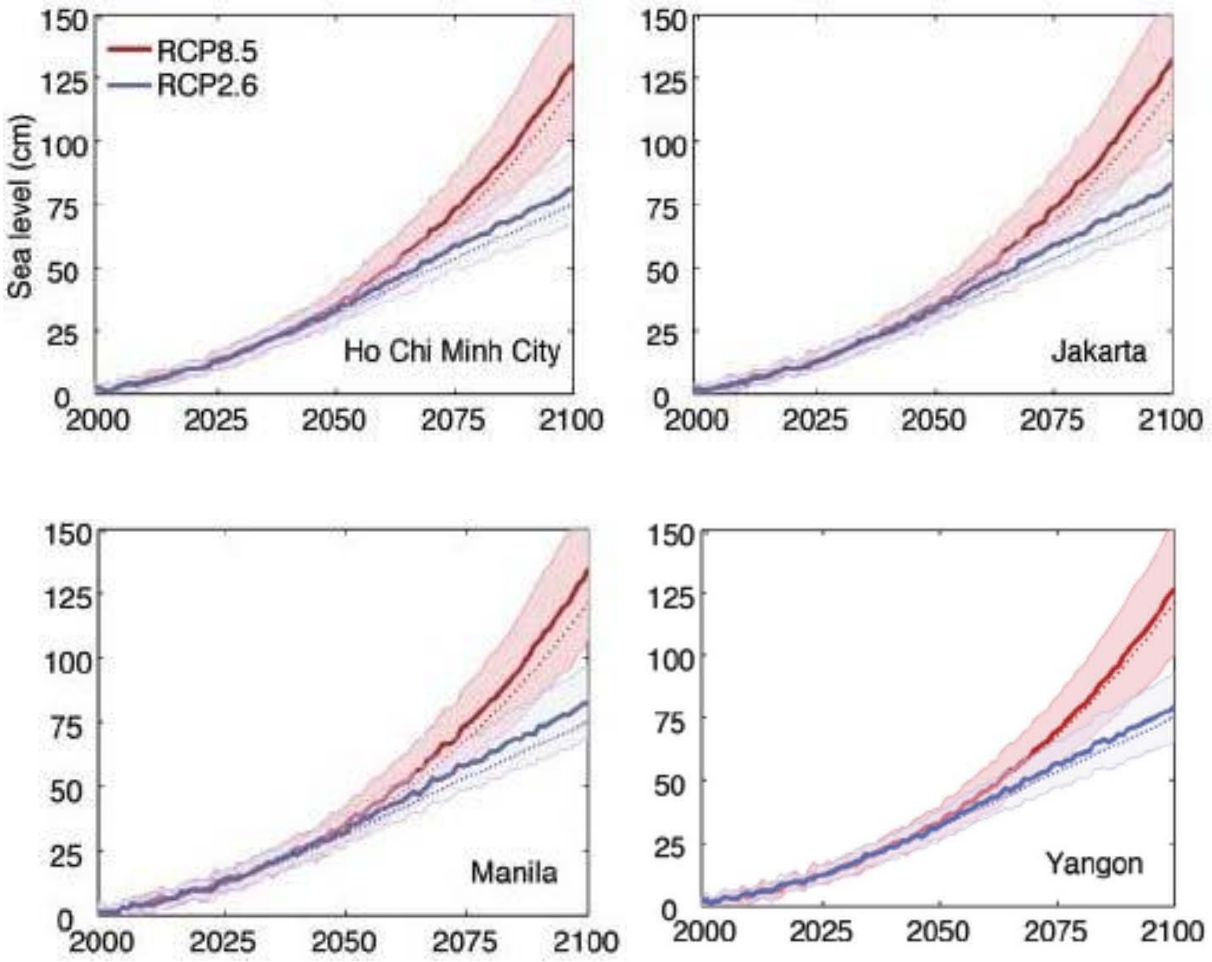


(Smajgl 2015)

7. Human settlements

Population centres in deltaic areas

- **Population centres in deltaic areas : exposed to high degree of cumulative climate-related risk (all environmental & socioeconomic factors).**



(ADB 2013)

Cities vulnerable to coastal flooding

- **By 2070 : SE Asian cities with most risk to coastal flooding include Ho Chi Minh City, Bangkok, Rangoon, Jakarta & Manila.**

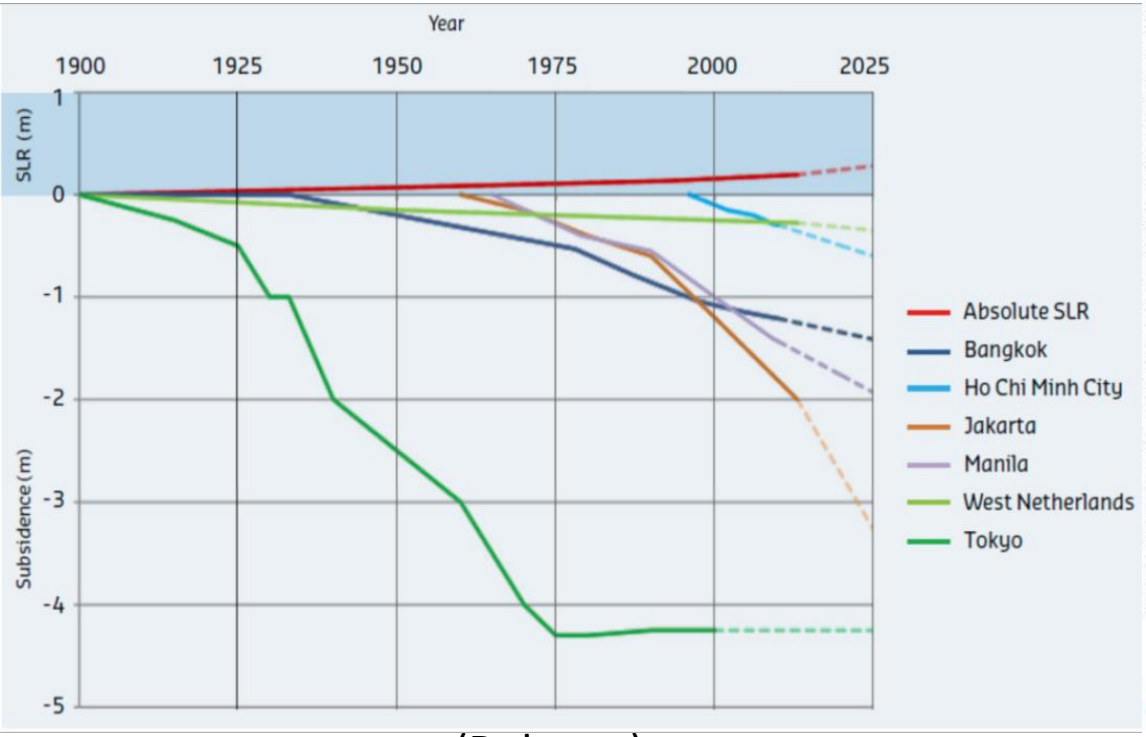
Key South East Asian Agglomerations	Population (2005, in millions)	Projected Exposed Population (2070, in millions)	Local Sea Level Rise Projections in a 4°C World in 2070 (above 1986–2005)
Jakarta	13.2	2.2	66cm
Yangon	4.1	4.9	63cm
Manila	10.6	0.5	66cm
Bangkok	6.5	5.1	65cm
Ho Chi Minh City	5.0	9.2	65cm

Source: Population data from Hanson et al. (2011); SLR RCP8.5 (in this report).

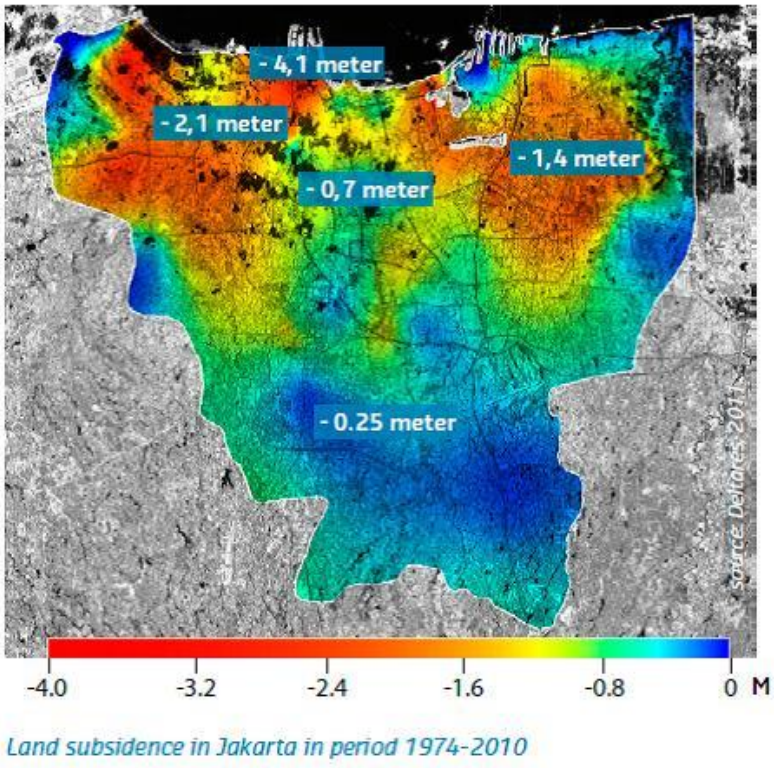
(ADB 2013)

Subsidence

- **Groundwater withdrawal & surface drainage for urban development: resulting in land subsidence in Bangkok, Jakarta, Manila, Ho Chi Minh, Semarang, etc, increasing hazard exposure to coastal inundation & SLR.**



(Deltares)



(CCOP)

Question

- **Which sector of your country is most affected by climate change?**
- **And what adaptation measures are being planned?**

8. Adaptation

Adaptation - freshwater

- Develop adaptive/integrated water resource management of the trade-offs balancing water availability against increasing demand.
- Diversify water supply sources including reuse & recycling, use of household-level water resources, e.g. roof water harvesting.
- Reservoirs partly mitigate seasonal differences & increase water availability for irrigation.
- In coastal areas, desalination of seawater or brackish water to supplement.
- Integrated water management within river basins to benefit countries.

Adaptation – food security

- **Crop breeding : for high temperature condition. Promising option. E.g. 9 salt-tolerant rice varieties in 2013 in Philippines.**

- **Aquaculture : better management practices for shrimp, pangasius catfish, brackish-water & nearshore aquaculture, marine cage culture (Thailand, Philippines, Indonesia, Vietnam).**

(IRRI)

(BFAR)

Adaptation – human settlements

- **Focus on solely adapting through physical infrastructure in urban areas requires complementary adapting planning, management, governance & institutional arrangements to deal with uncertainty & unprecedented challenges.**

- **Integrating DRR & CCA in urban development, urban planning.**

Urban development	• Integrate flood risk management into spatial planning to protect groundwater recharge zones and floodplains • Adopt building codes and infrastructure standards to consider changes such as new flood return periods • Prepare disaster preparedness plans that consider disruptions to services • Develop measures that address the needs of vulnerable populations
Transport	• Redesign or relocate road facilities • Add or redesign protective measures for road corridors and coasts • Increase drainage for road facilities against projected increases in precipitation and erosion • Ensure road access to hospitals and evacuation centers and distribution of relief where road infrastructure may be damaged during extreme events

(ADB 2013)

Adaptation - coasts

- **Creation of MPAs targetting areas where SST are projected to change least : increase resilience.**

- **Hard coastal defenses, such as sea walls, protect settlements at the cost of preventing adjustments by mangroves, salt marshes, & seagrass beds to rising sea levels.**

- **Landward buffer zones : for inland migration of mangroves & seagrasses.**

Adaptation and mitigation

- **Agroforestry practices : carbon storage, decrease soil erosion, increase resilience against floods, landslides & drought, biodiversity benefits, reduce financial impact of crop failure, etc.**

- **Very high carbon sequestration potential of organic-rich soils in mangroves & peat swamp forests.**

- **Sustainable cities with fewer fossil-fuel driven vehicles (mitigation) & more trees & greenery.**

EBA - Ecosystem-based management

- **Emerging approach using biodiversity & ecosystem services (supporting, provisioning, regulating, cultural) as part of overall strategy to adapt to adverse effects of climate change.**

- **Part of broader portfolio of adaptation measures – can be applied at different geographical scales & within various time frames.**

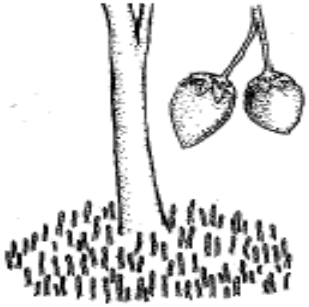
- **Is cost-effective to protect communities from climate change & extreme weather events.**

EBA for coasts and islands

- **"Natural ecosystems such as coastal forests, coral reefs, mangrove belts, beach ridges, sand dunes or forested slopes are effective barriers against many types of natural disasters. Such reinforcements can be a cost-effective insurance against storm surges, tsunami and sea-level rise for coastal communities that cannot afford expensive infrastructural protection." (*Planet Prepare* 2008: 63)**

Mangroves

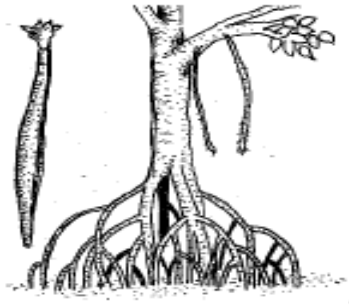
- **Have special root systems & may adapt to changes in sea level by growing upward in place, or by expanding landward or seaward.**



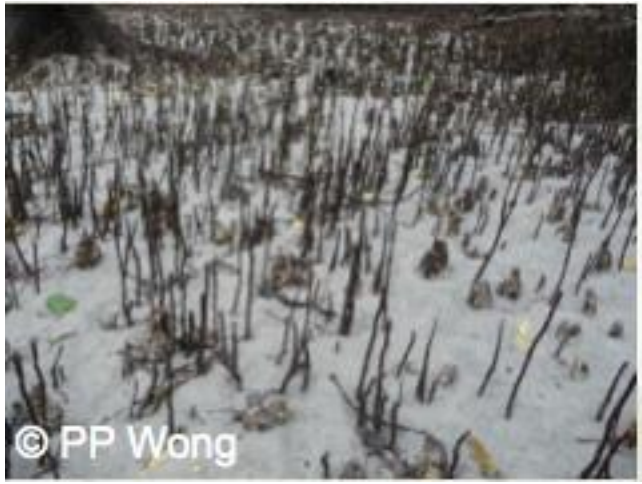
Peg roots of *Avicennia*

Knee Roots of *Bruguiera*

Peg roots of *Sonneratia*



Prop roots of *Rhizophora*



Buffer to waves

- **Publications on experiments & field studies done on effectiveness of mangroves (Mazda et al 2007).**
- **Review by Cochard et al (2008) summed up & put controversy to rest to some extent. Considerable buffer to waves up to 4 m high.**
- **Reduce wave ht & energy by 13% to 66% & surges by 50 cm for every km, as they pass through trees & exposed roots.**

Ecosystem type	Dominant ecosystem processes	Dominant buffer composition	Approximate wave buffer effectiveness range				Expected tsunami energy exposure
			Normal waves	Storm waves	<4 m high tsunami	>8 m high tsunami	
(c) Mangrove forests	Biotic/ physical	Biotic	▼~▼[1]	▾~▼[1,8]	▾~▼[8]	▲~▼[8]	▮–▮

Legend:

▲ Hazard amplification
▼ Hazard mitigation
X No effect

▾ ▲ Slight effect (not evident, but measurable)
▼ Moderate effect (evident, ~20–50% energy reduction)
▼ Considerable effect (~50–100% energy reduction)

▮ Small
▮ Medium
▮ High

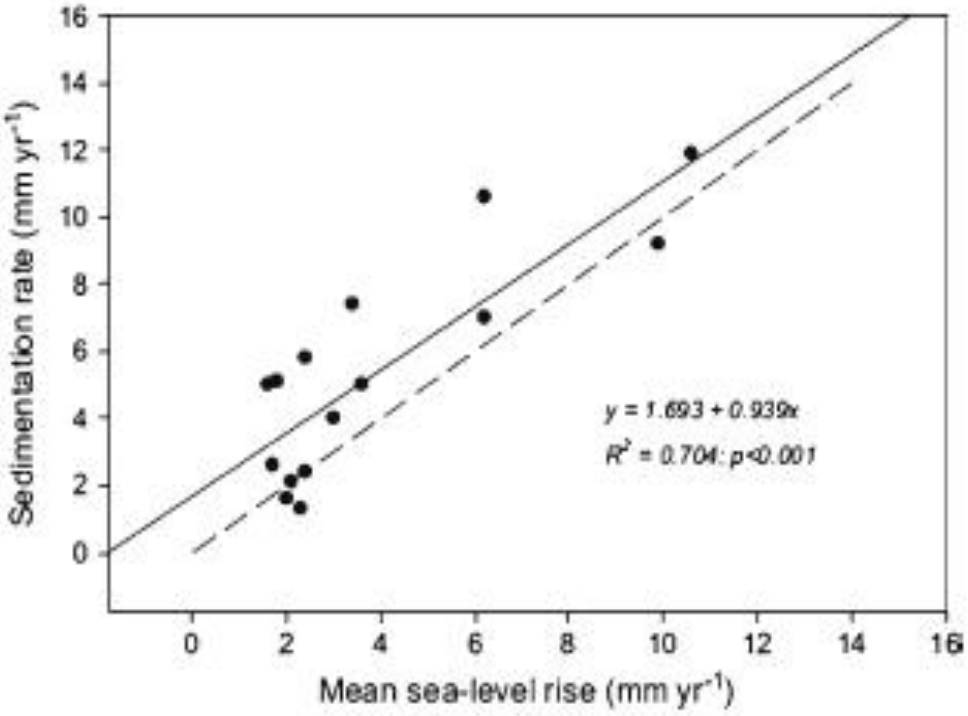
(Cochard et al 2008)

Keeps up with SLR

- **Keeps up with SLR : 1 mm/annum.**

- **"Intact and healthy mangrove systems can adapt to sea level rise; their growth can accommodate to increases of 3.8 up to 9 mm per year depending on local circumstances."**

(Wetlands International)



(Alongi 2008)

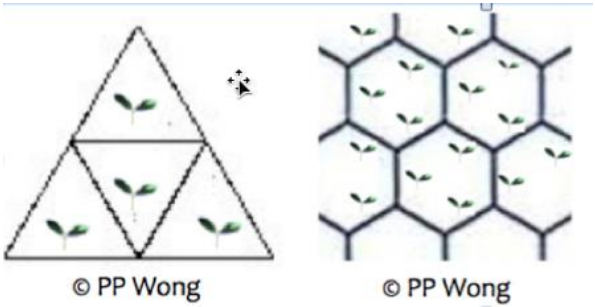
Large-scale modular planting (1)

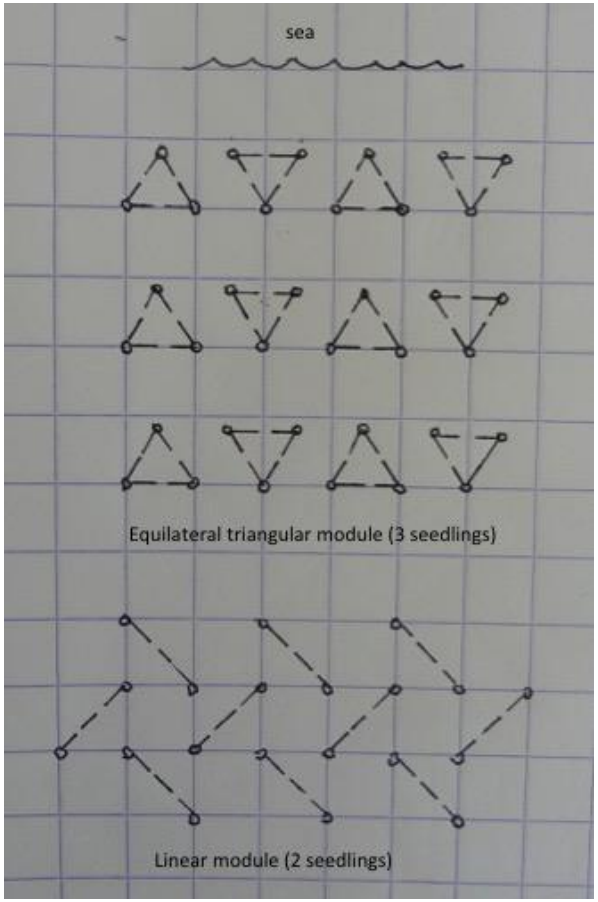
- Large-scale planting using modular system to meet requirements of various coastal locations. Modular system of planting & deployment is comparable to LEGO® set on large scale.

- Ideally space-fitting shapes containing sediments with mangroves grown to various heights. Modules made of local materials or mixture of compressed sediments that become self-destructive & formed part of substrates. Nutrients & sediments added to growing mangroves in field (Wong 2011).

- Suitable for variety of coasts & not confined to muddy coasts.

Large-scale modular planting (2)





© PP WONG

Avicennia marina

- **Widest latitudinal range, ability to adapt to wide range of physical conditions, only mangrove to survive in arid areas.**
- **Present on both seaward & landward margin of mangrove belt.**
- **'Opportunistic' colonization due to ecological characteristics.**
- **Grows on mud, sand, gravels, rocks, rock surfaces.**

Adaptation = Development

- Modules for mangrove seedlings is moving to higher level of development for the villages, as suitable materials have to be sourced, adapted & manufactured.
- Small machine shops to produce modules in larger numbers & in standardized format, thus pushing development to a higher level. More skills to be developed as modules are then deployed to coasts.
- When mangroves are fully grown, forests themselves could open opportunities for villages to another level of development, e.g. ecotourism development.
- Timeline from mangrove seedlings to their maturity along coasts generates increasing levels of development/opportunities for villages & at same time improves adaptation to SLR.

Winner of MIT Climate CoLab, 2014

Climate change and SDGs

- **Effects of climate change** are projected to worsen over SDGs' 15-year timeframe (2016-2030), regardless of extent of emissions cuts now, because of delayed warming effect from past emissions.
- **Urgent action** is required to achieve a peak & decline of emissions before 2020.

ADB update : conclusions for low carbon economy

- **90% share of five SE Asian countries (Indonesia, Malaysia, the Philippines, Thailand, & Viet Nam) in total GHG emissions in the SE Asian region.**
- **11% estimated decline in GDP in SE Asia by 2100 due to climate change, 60% higher than ADB's earlier assessment.**
- **5% annual increase in GHG emissions from 1990 to 2010 due to the region's rapid growth.**
- **At least 60% projected increase in GHG emissions by 2050 if there will be no explicit policies to cut future emissions.**
- **2.5 to 3.5% cost to regional GDP over the 2010-2050 period of policies to mitigate GHG emissions.**
- **Nearly 3% share of 2050 GDP as co-benefits as policy changes on energy & land use lead to benefits such as improved health, reduced transport congestion, & reduced vehicular accidents.**
- **5 to 11 times net benefits from climate change initiatives far outweighing the net cost of mitigation from 2010-2100.**

Thank you

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