THE CHALLENGES OF ASSESSING ECOSYSTEM VULNERABILITY TO CLIMATE CHANGE

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Center for International Forestry Research

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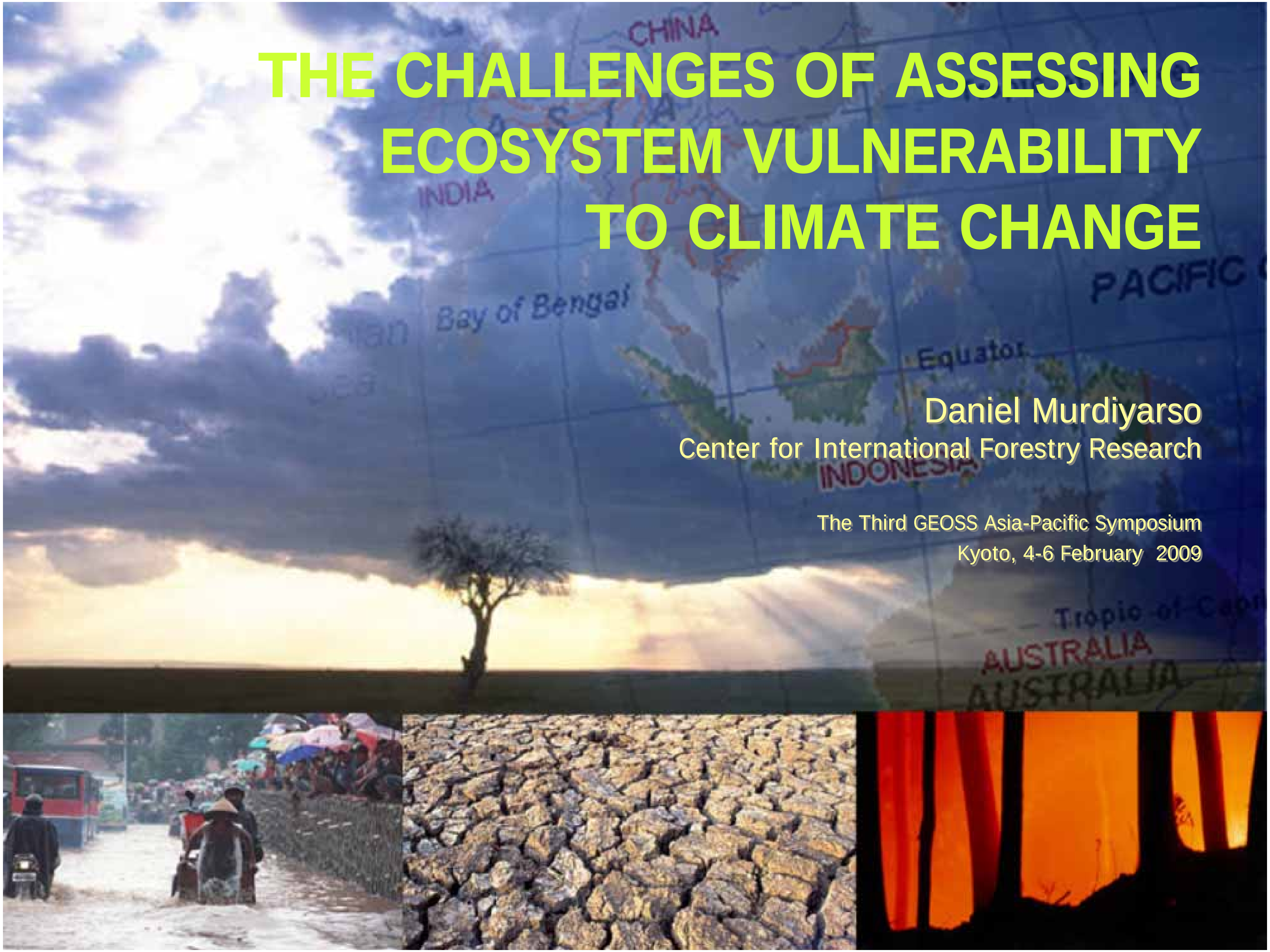
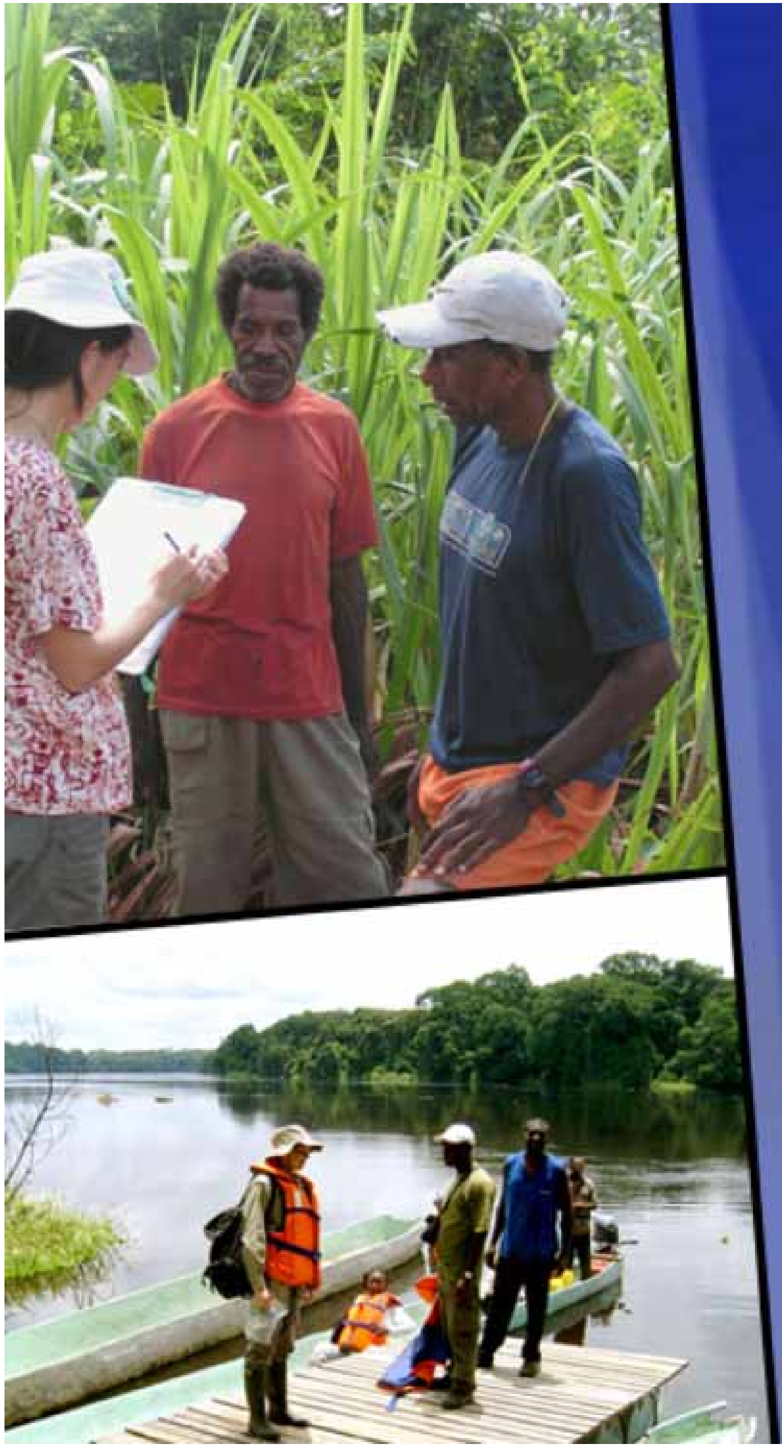


A quick introduction to CIFOR:

- One of 15 centers in the CGIAR
- Focus on forest policy research
- Headquarters in Bogor, Indonesia
- Staff also based in Brazil, Bolivia, Burkina Faso, Cameroon, Ethiopia, Zambia, Laos, Nepal
- Research activities in more than 40 countries throughout the tropics



CIFOR's global research agenda:

- Forests and climate change mitigation
- Forests and adaptation to climate change
- Small-scale and community forestry
- Conservation and development at landscape scale
- Impacts of trade and investment on forests
- Sustainable management of production forests

The context

1. Monitoring and predicting climate change
2. Water cycle in the Asia-Oceanic region
3. Monitoring changes in ecosystems, biodiversity and ecosystem services
4. Earth observation and data sharing for disaster management

Inter-disciplinary sessions

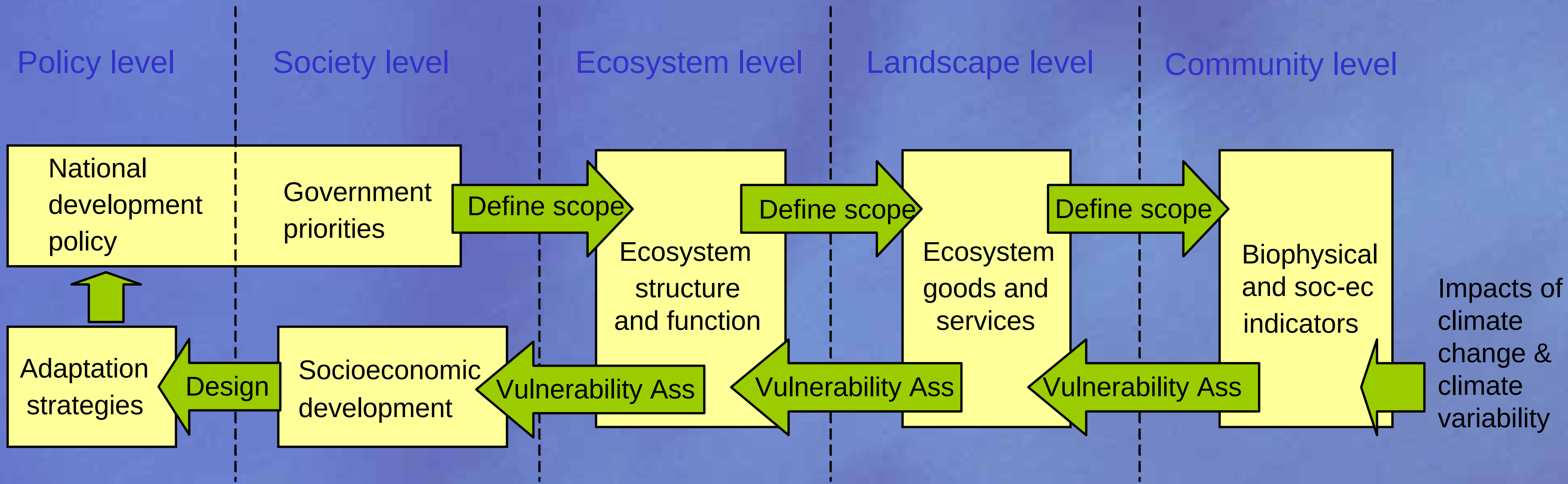
- Toward collaboration among climate, water and disaster societal benefit areas (SBAs)
- Necessity and possibility of observation, forecasting, and data sharing through the interdisciplinary collaboration of “ecosystem – climate change – disaster”

- Ecosystem → Climate change → Disaster
- Observation → Forecasting → Data sharing

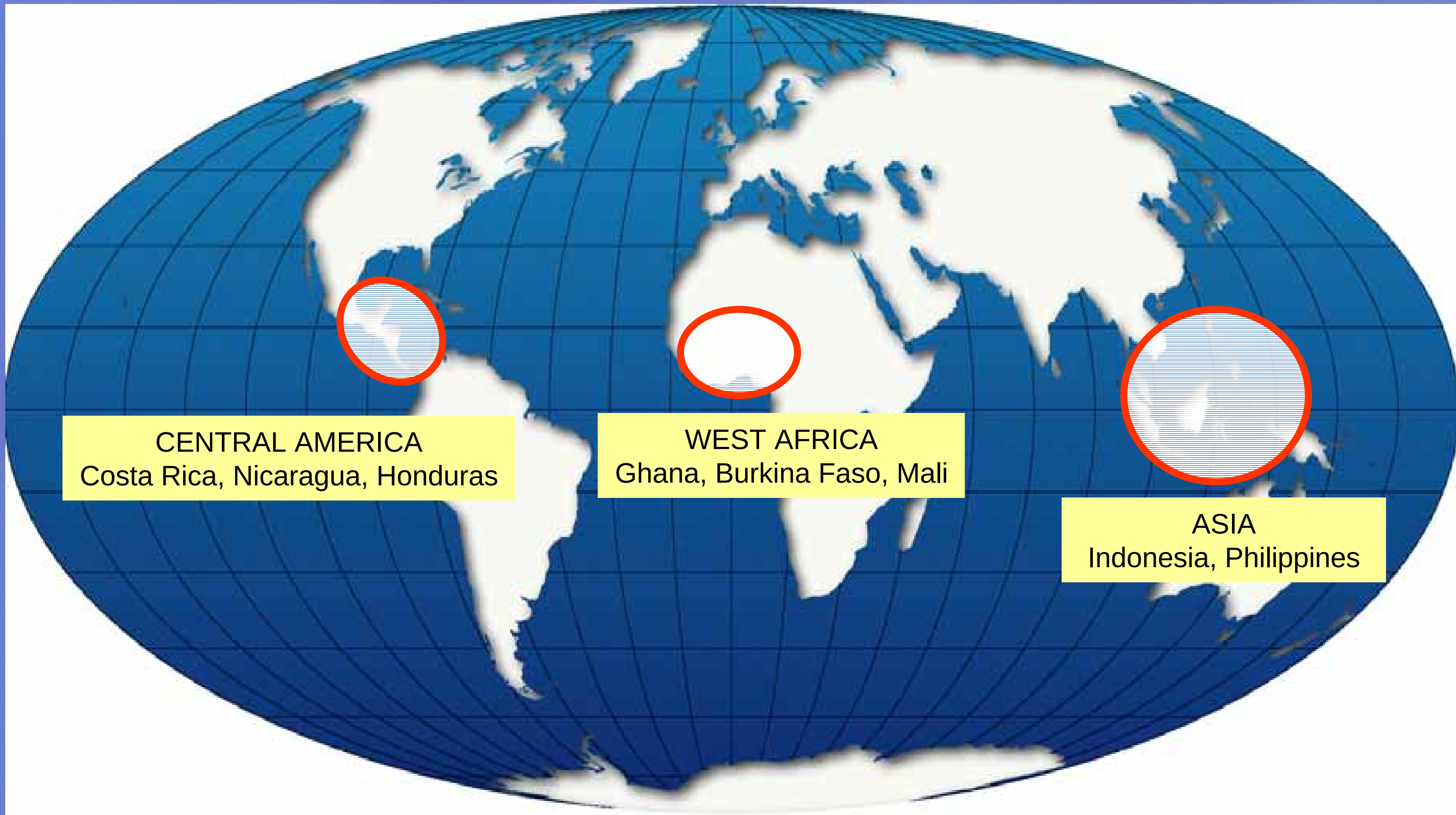
Outline

- Introduction
- Why ecosystem approach?
- How can ecosystem vulnerability be assessed?
- Where is the vulnerable ecosystem?
- What’s next?: linking adaptation – mitigation
- Who should be involved in data sharing?
- Summary

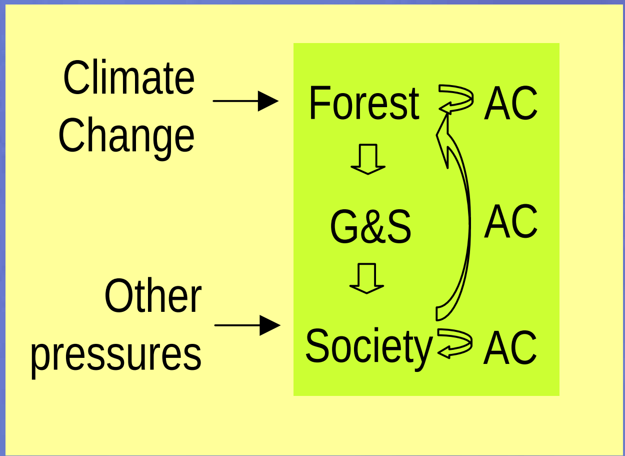
Why ecosystem approach?



TroFCCA – Field test sites



Vulnerability assessment



Vulnerability, V = *f* (E, S, AC)

E = Exposure (CC, other stressors)

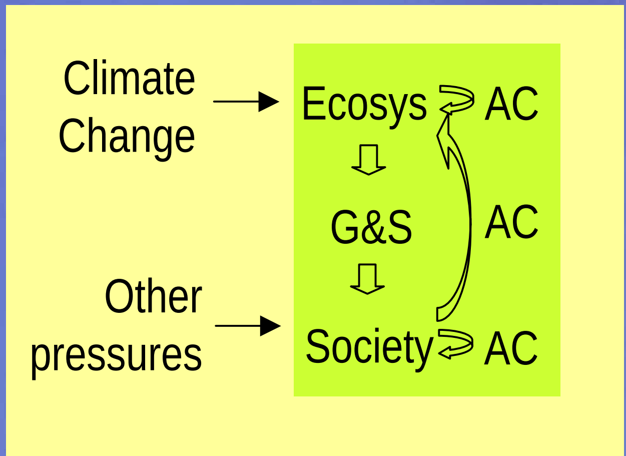
S = Sensitivity (rainfall, vegetation cover)

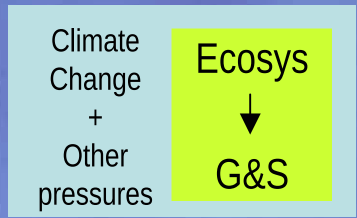
AC = Adaptive Capacity (of the components)

(Metzger et al. 2006)

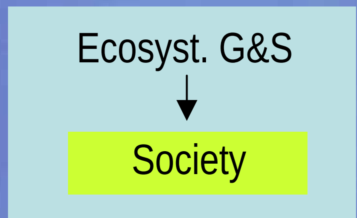
Guiding principles

Assessing vulnerability → Split into 3 Principles (of sub-systems)

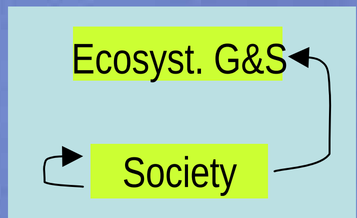




P1: Provision of relevant ecosystem goods and services are vulnerable to climate change and climate variability



P2: The social system is sensitive to changes in the provision of goods and services

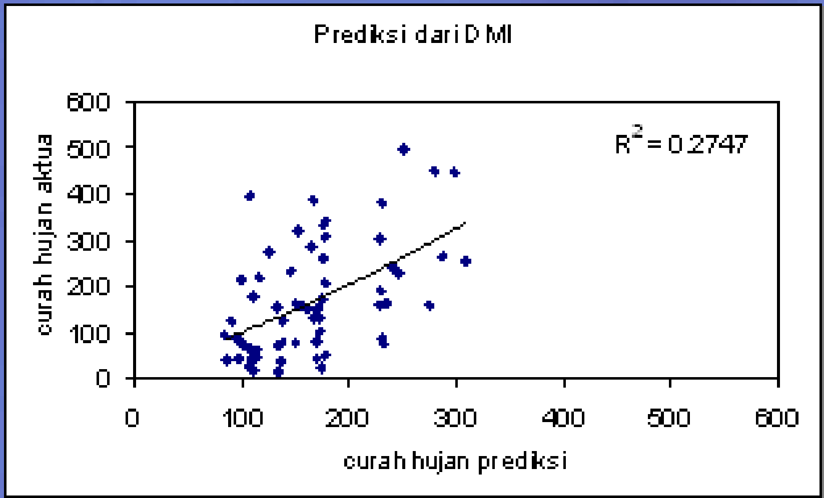


P3: The governance system is lacking adaptive capacity to respond/avoid changes in goods and services

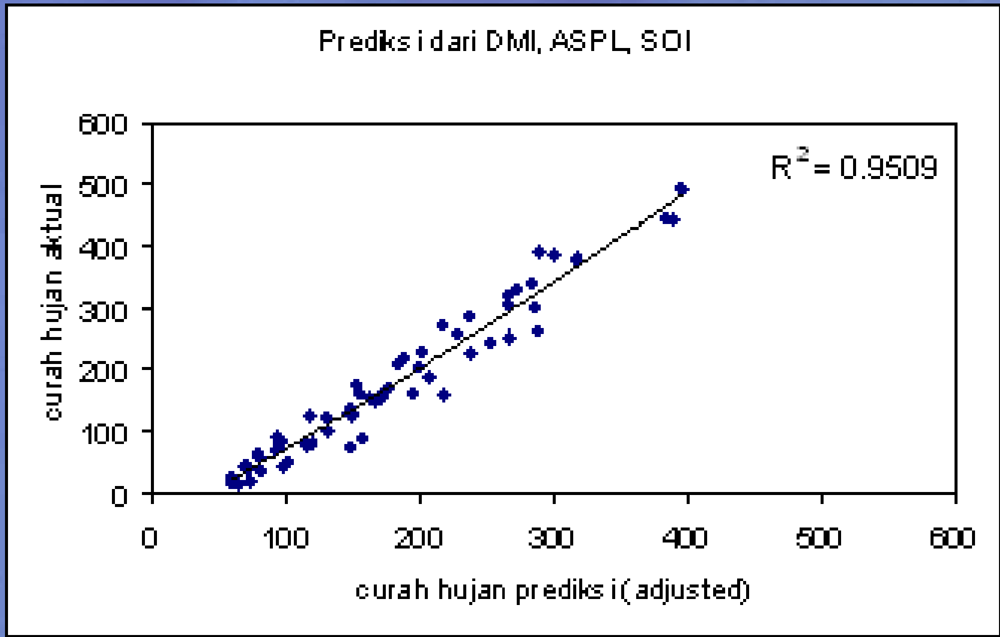
Developing Criteria & Indicators

Principles → Criteria	Possible Indicators (fire)
P1. Provision of relevant ecosystem goods and services are vulnerable to climate change and climate variability **C11.** Ecosystem goods and services are exposed and sensitive to climate variability and climate change **C12.** Given the state and pressure on ecosystem, natural adaptive capacity is low	• Drought correlates with fire frequency • Climate is not the only cause of fires • Other biophysical parameters control the frequency, intensity and distribution of fires (fuel availability and type, canopy cover, connectivity)
P2. The social system is sensitive to changes in the provision of relevant goods and services **C21.** The social [human] system is highly dependent to the relevant goods and services **C22.** Sustainable and cost-effective substitutes for the lost goods and services are not available	• Fire effects on people livelihoods • Societal responses • Returns to land and labour
P3. The social and governance system is lacking adaptive capacity to respond/avoid changes in good and services **C31.** The social system is lacking adaptive capacity to respond to or to avoid changes in good and services **C32.** Policies increase vulnerability	• Effectiveness of implementation of regulations and laws, • Level of education, implementation of non-adaptive regulations/ policies, • Government effectiveness and efficiency affect the effectiveness of fire prevention and water management.

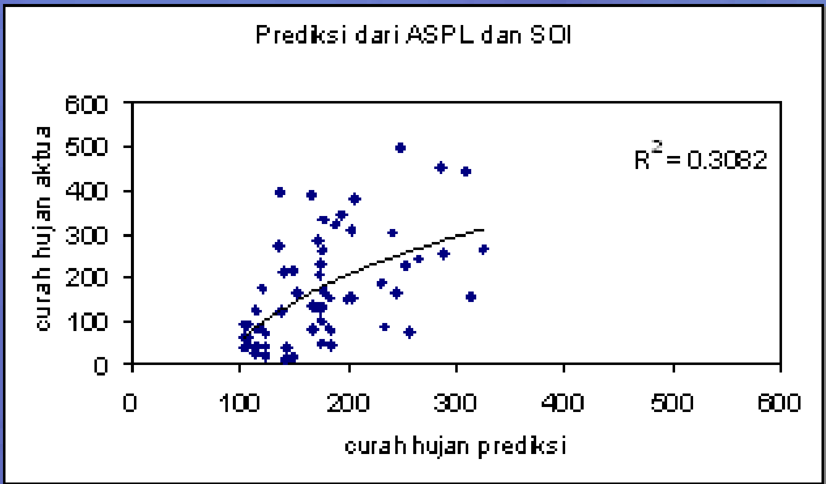
Validation of rainfall predictions



Predictor: IDME

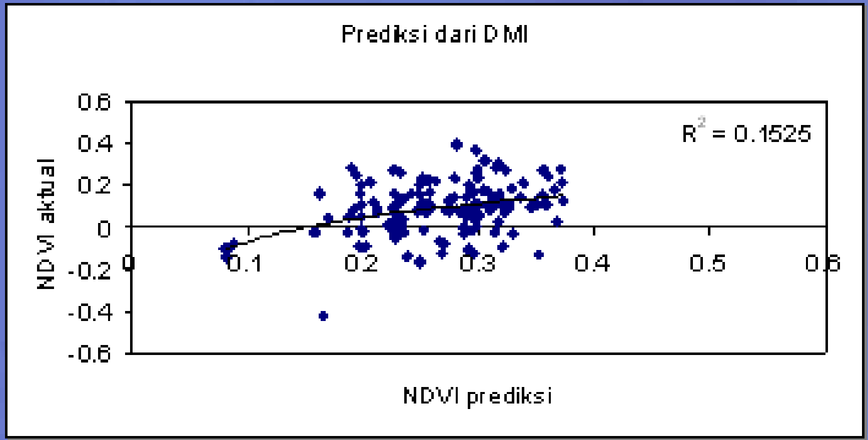


Predictor: IDME & ENSO

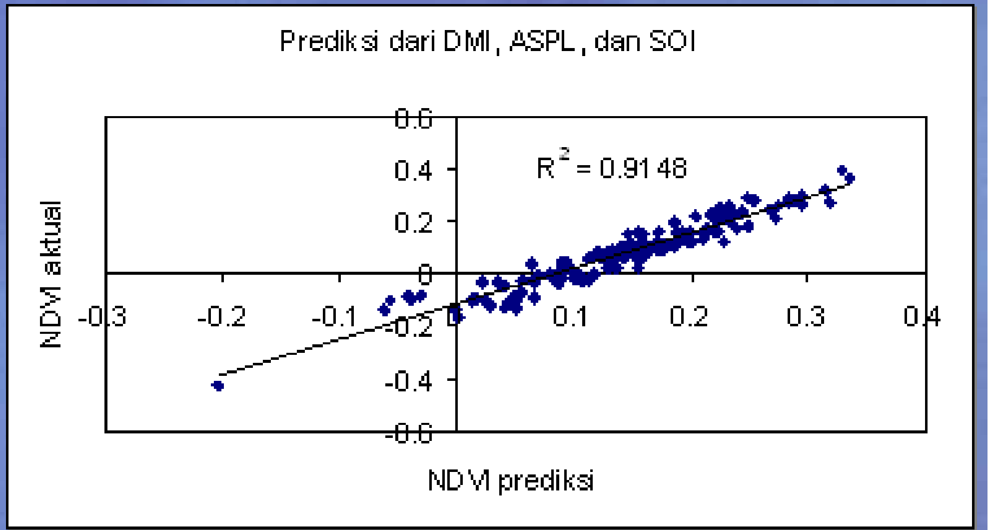


Predictor: ENSO

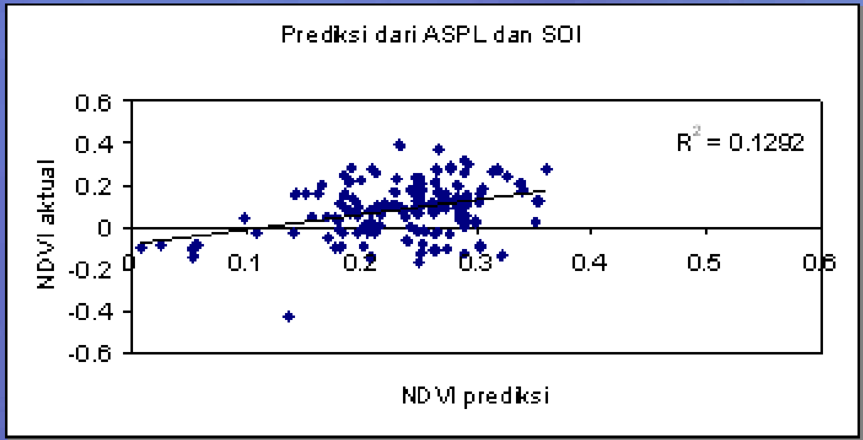
Validation of NDVI predictions



Predictor: DME

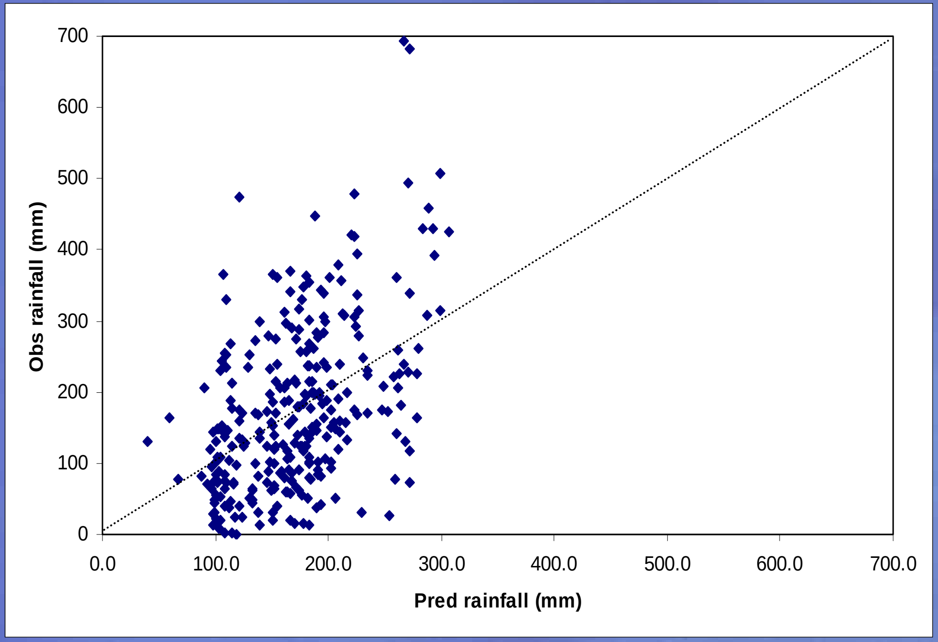


Predictor: DME & ENSO

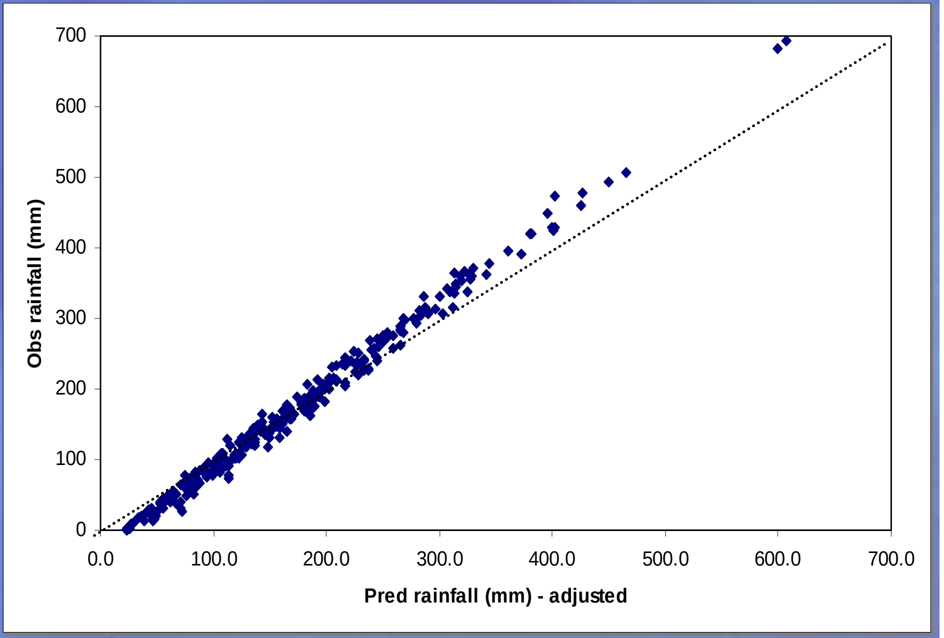


Predictor: ENSO

Predicted vs observed rainfall with 1 month time lag

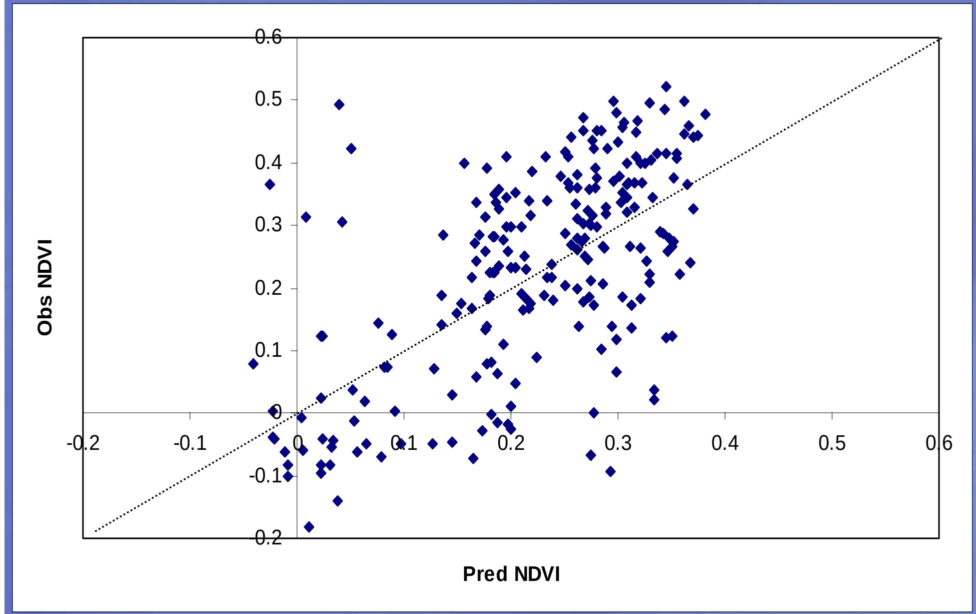


Before adjustment

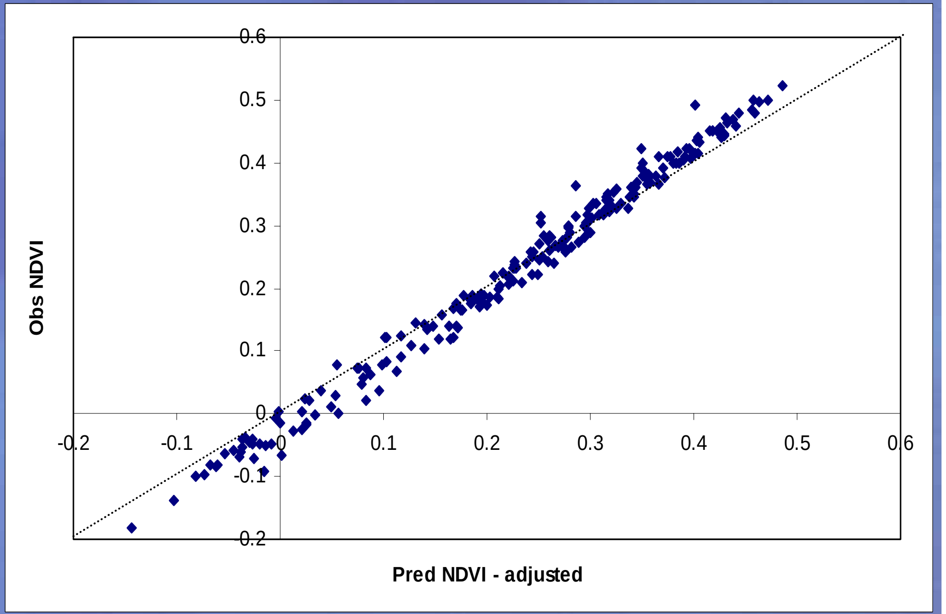


After adjustment

Predicted vs observed NDVI with 1 month time lag

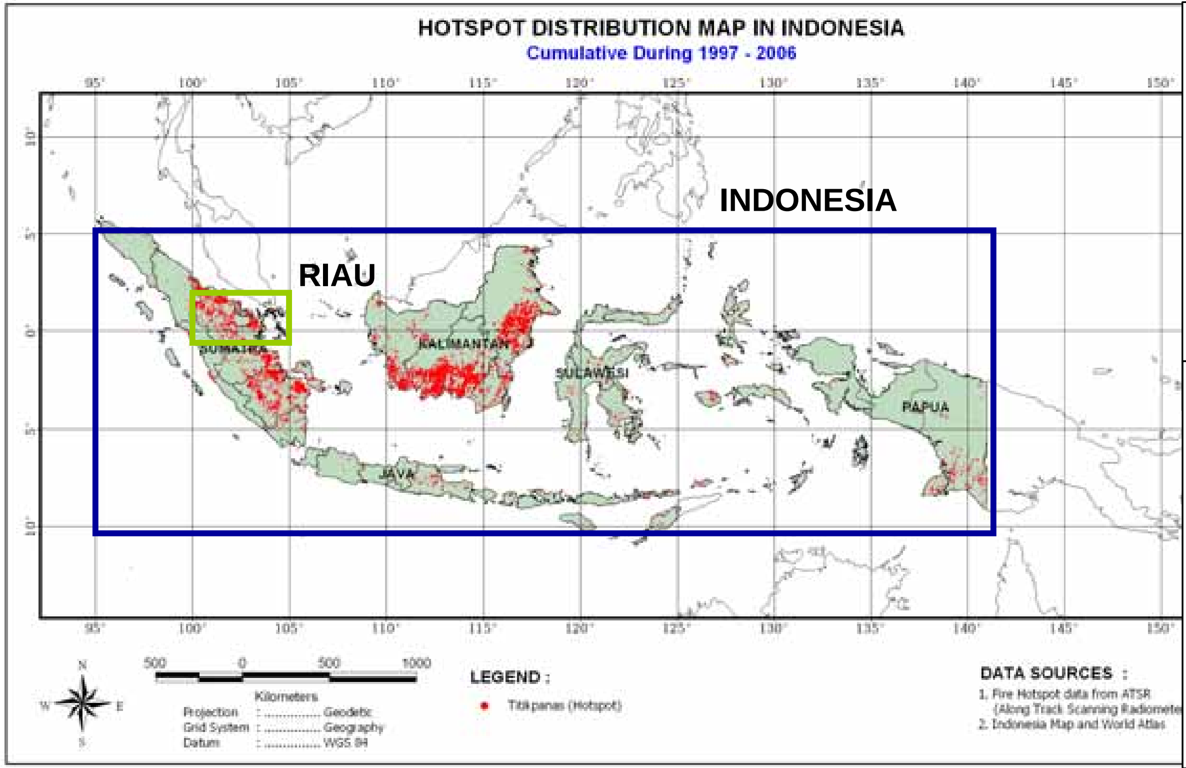


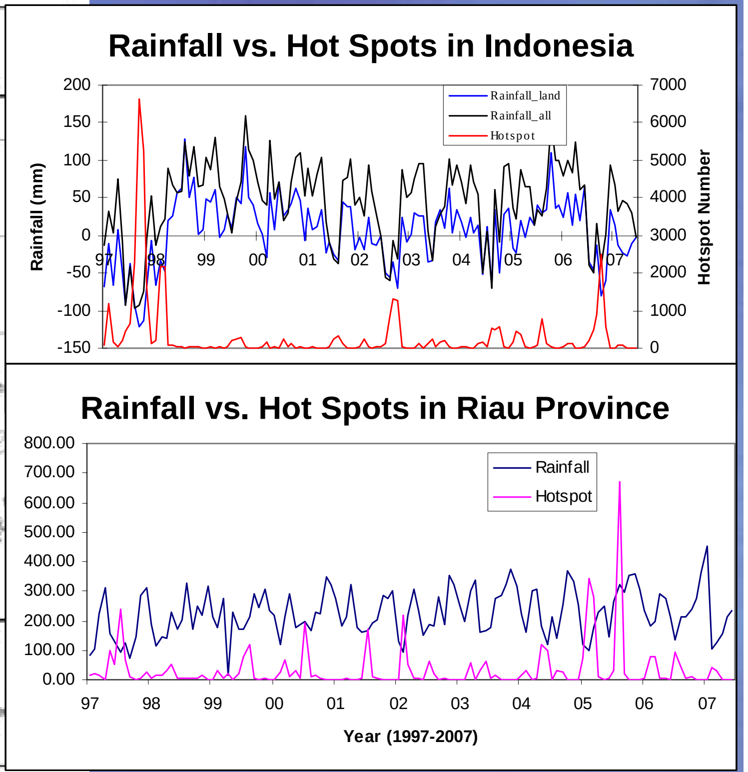
Before adjustment



After adjustment

Observing hotspots – good predictor?



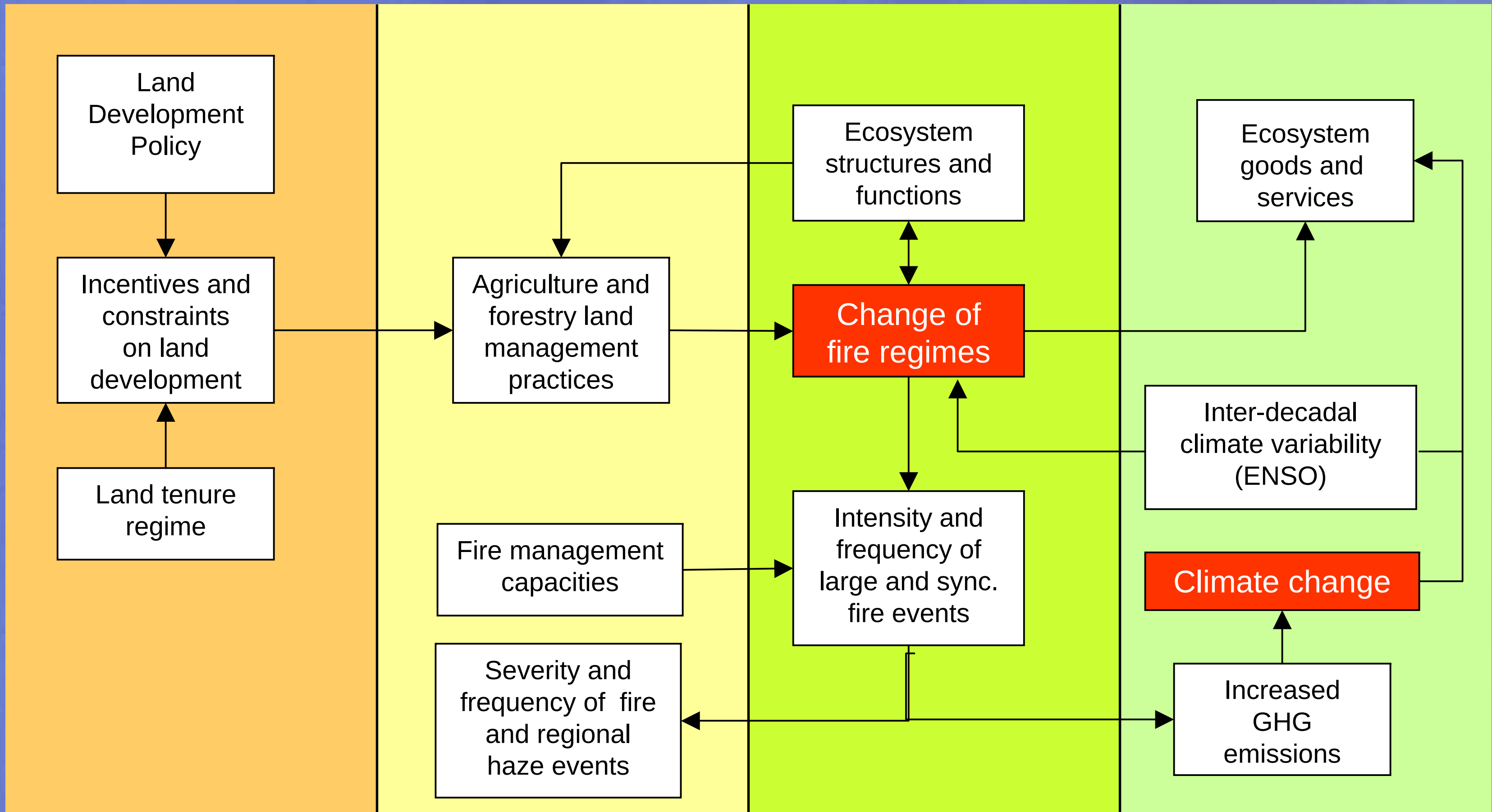


- Correlation between rainfall anomaly and hotspot occurrence is significant for Indonesia (country-wide), but less significant for Riau Province
- Probability of high to very-high fire risk drops with the increase of rainfall from 33.3% (below normal) to 16.7% (normal), and to 4.8% (above normal)
- Hotspot occurrences were repeatedly observed at about the same areas

Lessons learned

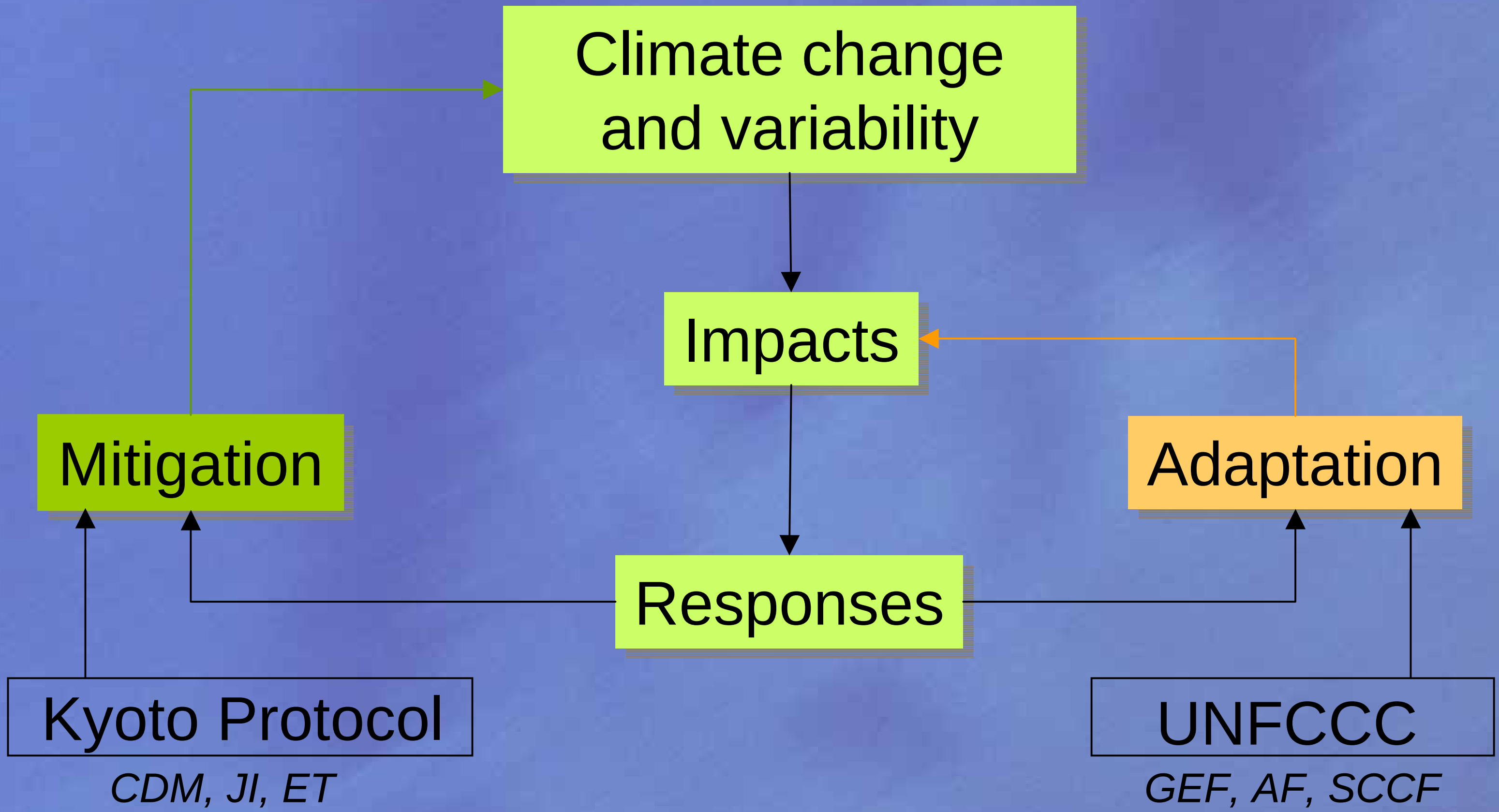
- Land-use change is an important driver
- Most fires are intentionally started as a cheap method for land clearing
- Prolonged drought leads to increasing widespread and uncontrolled fires
- Peatlands are the most vulnerable ecosystems

Process-based approach



Adaptation ← Vulnerability ← Impact ← State-of-the-art Risk to hazard

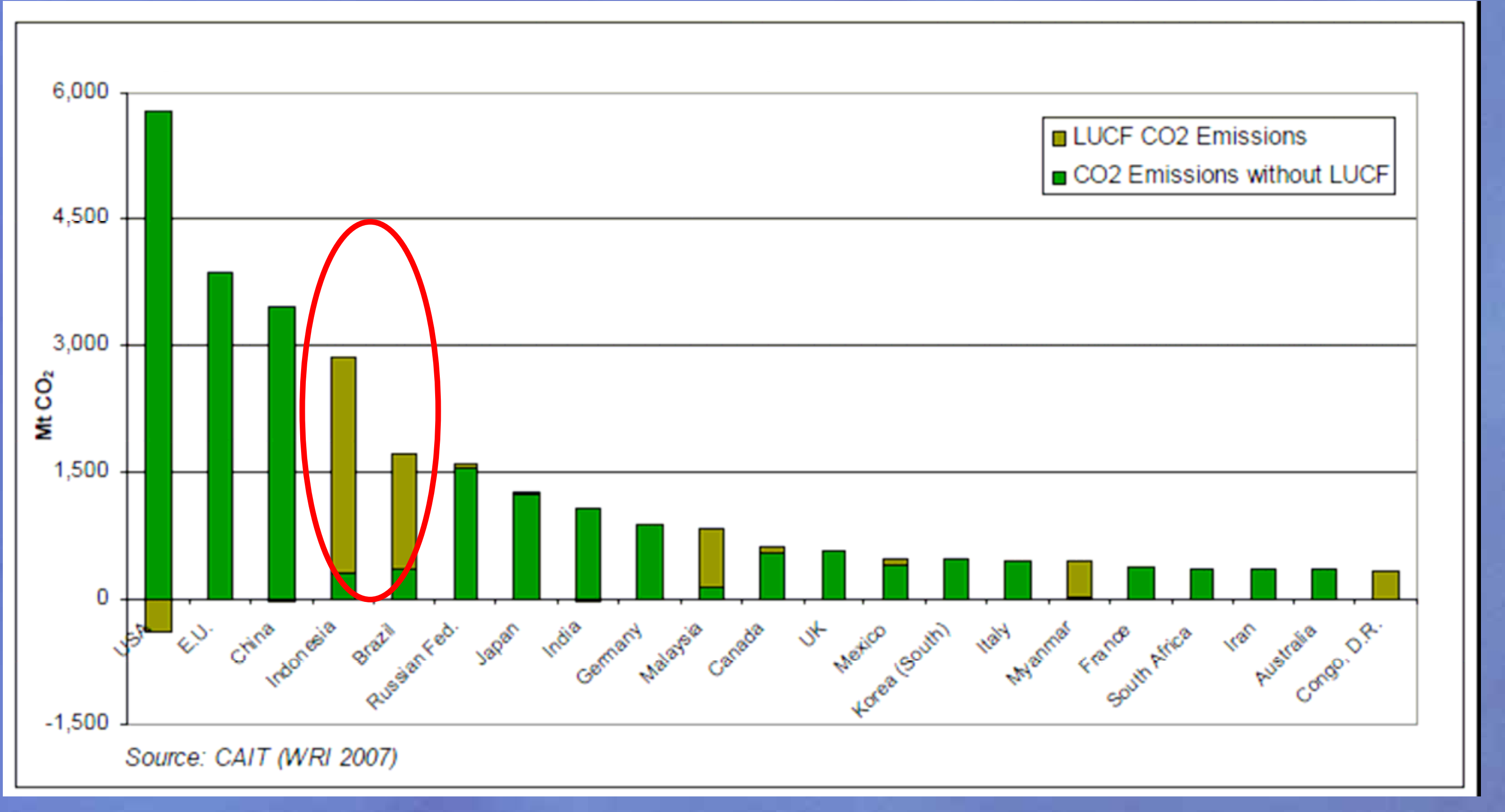
Linking adaptation and mitigation



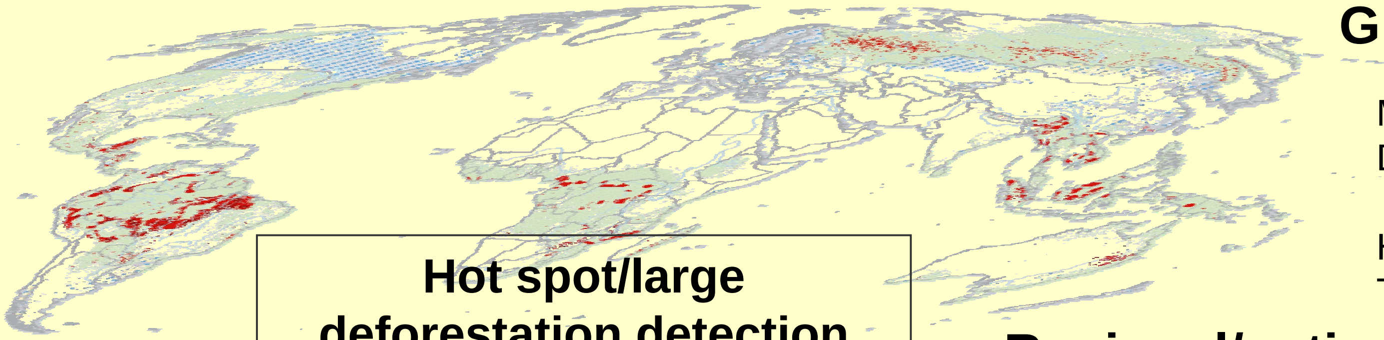
What's next?

- Forests are important for climate mitigation
- Some 20% of global emissions are from deforestion and land-use change
- Indonesia and Brazil are now globally-significant sources of emissions due to deforestation and forest fires
- Most of terrestrial carbon in Asia-Pacific are stored in peatlands ecosystems

Total CO2 emissions in 2000 (Top 21 emitters)



Measurement and monitoring



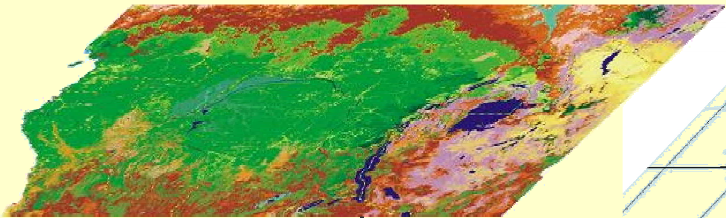
Global observations

MODIS/MERIS-type sensors
Deforestation (<10-20 ha)
(intra-) annual
Hot spots of forest change
Top-down standards

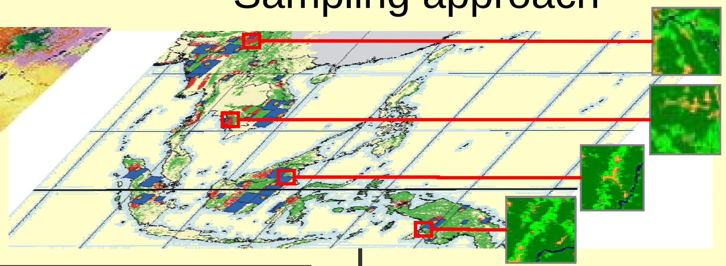
Hot spot/large deforestation detection

Regional/national observations

Wall-to-wall mapping



Sampling approach



Landsat/Spot-type / SAR
Deforestation (<0.5-1 ha)
(inter-)annual
Regionally-tuned forest degradation mapping
Bottom-up flexibility

Change in forest area and density

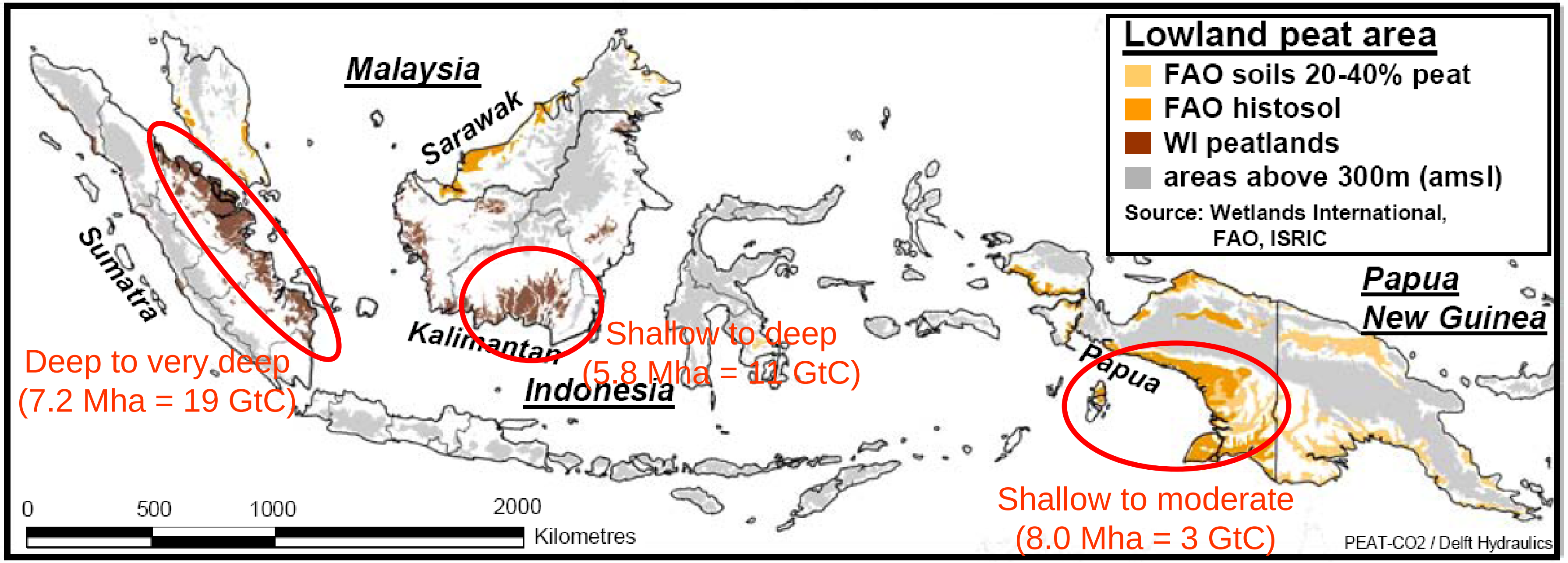
Fine-scale/in-situ observations

Estimation of carbon emissions

Nat./Reg. forest inventories
In-situ/plot data
Targeted remote surveys
FAO statistics
Models relating forest change to C-emissions
IPCC-LULUCF / AFOLU

Courtesy of: GOFC-GOLD

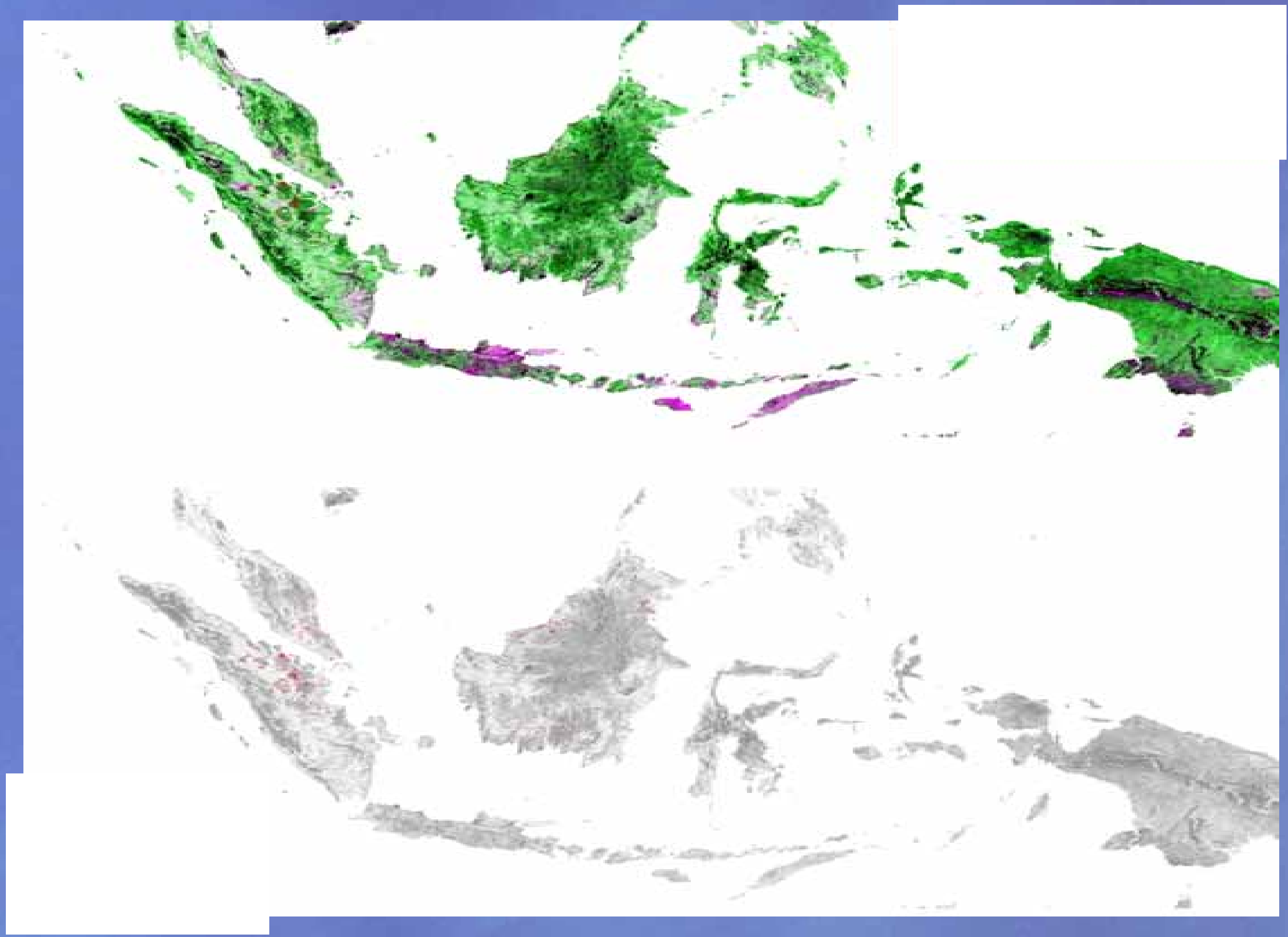
Where are the hotspots located?



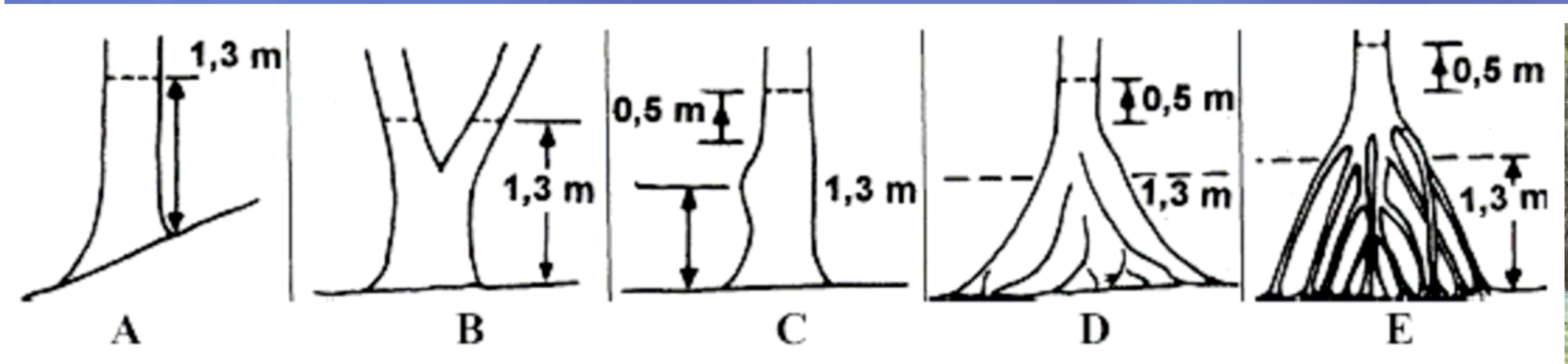
		1990	2002
Global	400 Mha (528 Pg)		
Tropics	40 Mha (191 Pg)		
SE Asia		35-40 Mha	25-30 Mha
Indonesia		21 Mha (33 Pg)	17 Mha (?)

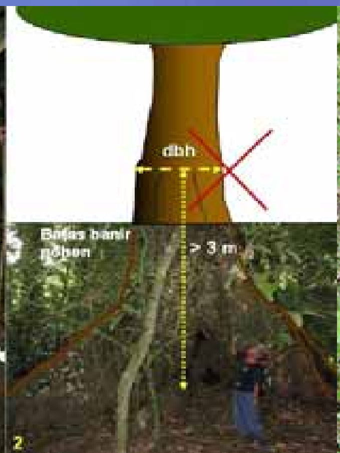
Shallow:	0.5 – 1 m
Moderate:	1 – 2 m
Deep:	2 – 4 m
Very deep:	2 – 4 m
Extremely deep:	> 8 m

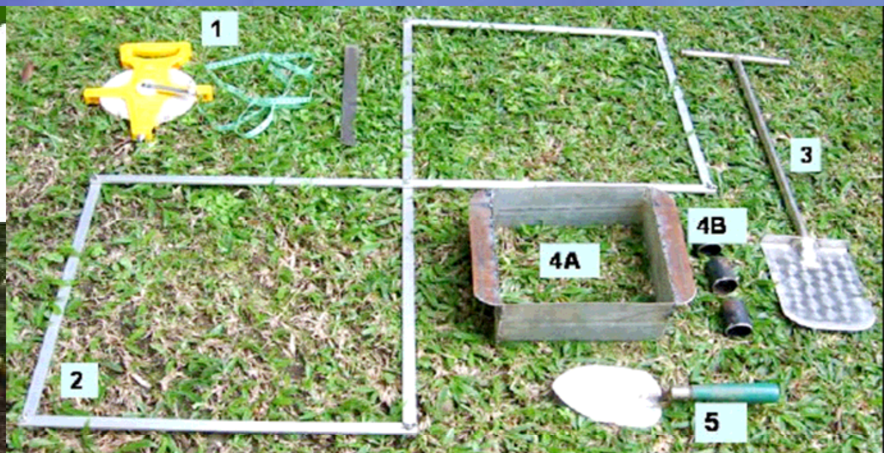
Wall-to-wall to avoid leakage



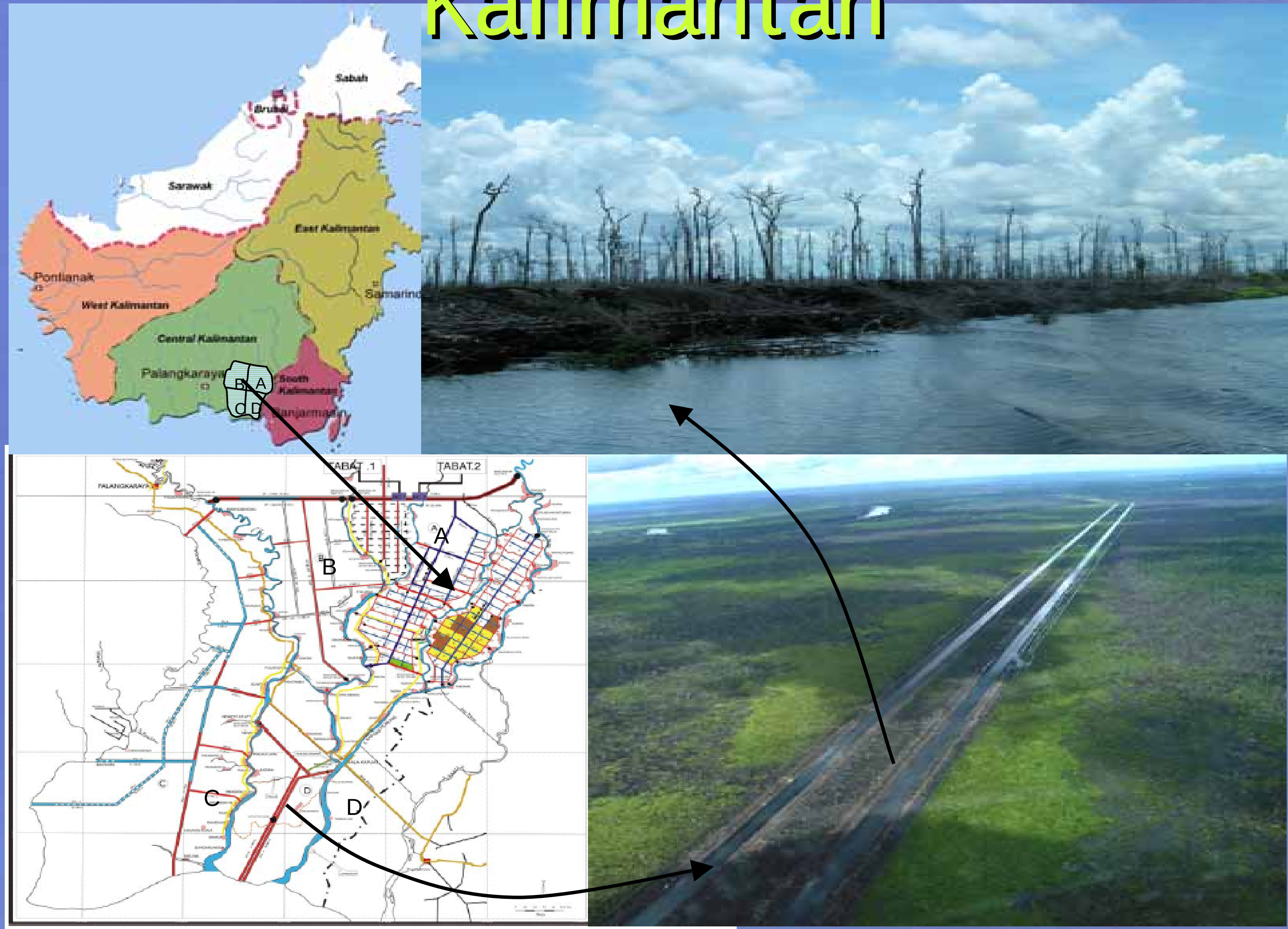
The challenges of ground-truthing



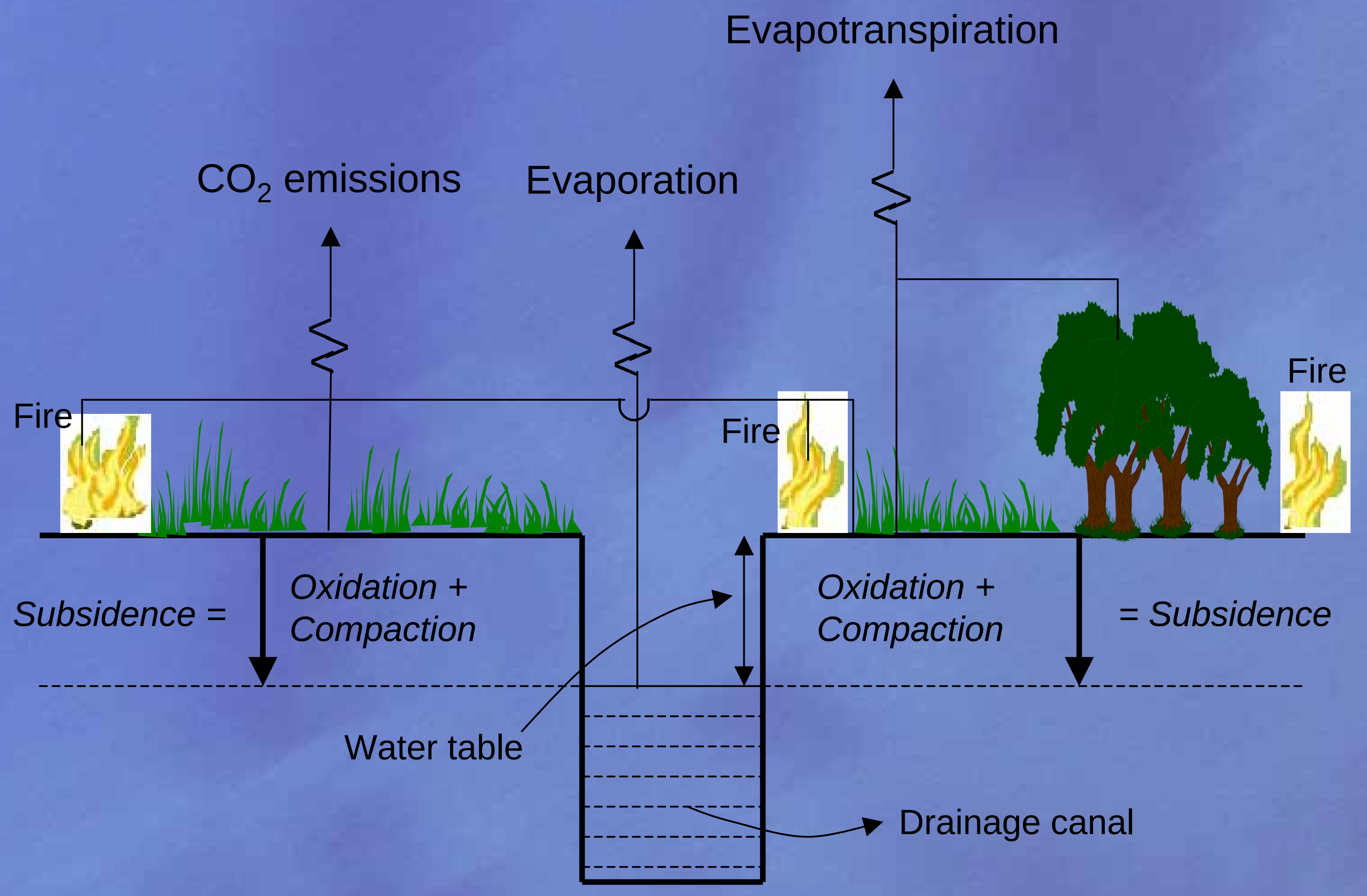




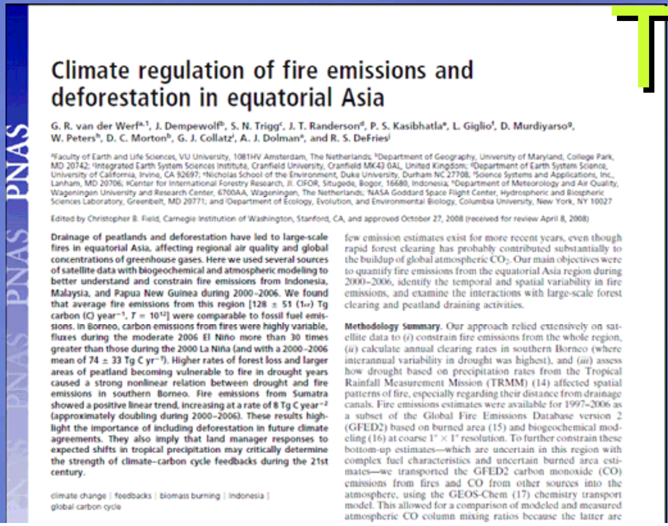
Ex-Mega Rice Project – C. Kalimantan



Water and fire management are crucial



Top-down approach


PNAS

Climate regulation of fire emissions and deforestation in equatorial Asia

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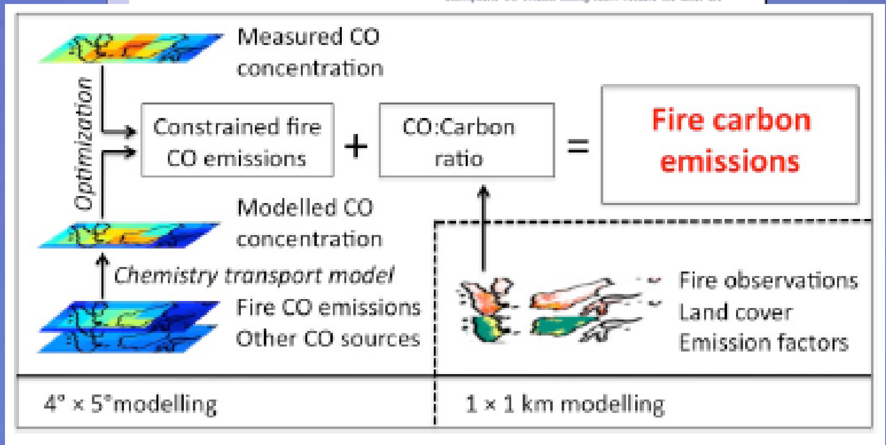
Drainage of peatlands and deforestation have led to large-scale fires in equatorial Asia, affecting regional air quality and global concentrations of greenhouse gases. Here we used several sources of satellite data with biogeochemical and atmospheric modeling to better understand and constrain fire emissions from Indonesia, Malaysia, and Papua New Guinea during 2000–2006. We found that average fire emissions from this region [128 ± 51 (1σ) Tg carbon (C) year^{-1}, $T = 10^{12}$] were comparable to fossil fuel emissions. In Borneo, carbon emissions from fires were highly variable, fluxes during the moderate 2006 El Niño more than 30 times greater than those during the 2000 La Niña (and with a 2000–2006 mean of 74 ± 33 Tg C yr^{-1}). Higher rates of forest loss and larger areas of peatland becoming vulnerable to fire in drought years caused a strong nonlinear relation between drought and fire emissions in southern Borneo. Fire emissions from Sumatra showed a positive linear trend, increasing at a rate of 8 Tg C year^{-2} (approximately doubling during 2000–2006). These results highlight the importance of including deforestation in future climate agreements. They also imply that land manager responses to expected shifts in tropical precipitation may critically determine the strength of climate–carbon cycle feedbacks during the 21st century.

climate change | feedbacks | biomass burning | indonesia | global carbon cycle

few emission estimates exist for more recent years, even though rapid forest clearing has probably contributed substantially to the buildup of global atmospheric CO_2. Our main objectives were to quantify fire emissions from the equatorial Asia region during 2000–2006, identify the temporal and spatial variability in fire emissions, and examine the interactions with large-scale forest clearing and peatland draining activities.

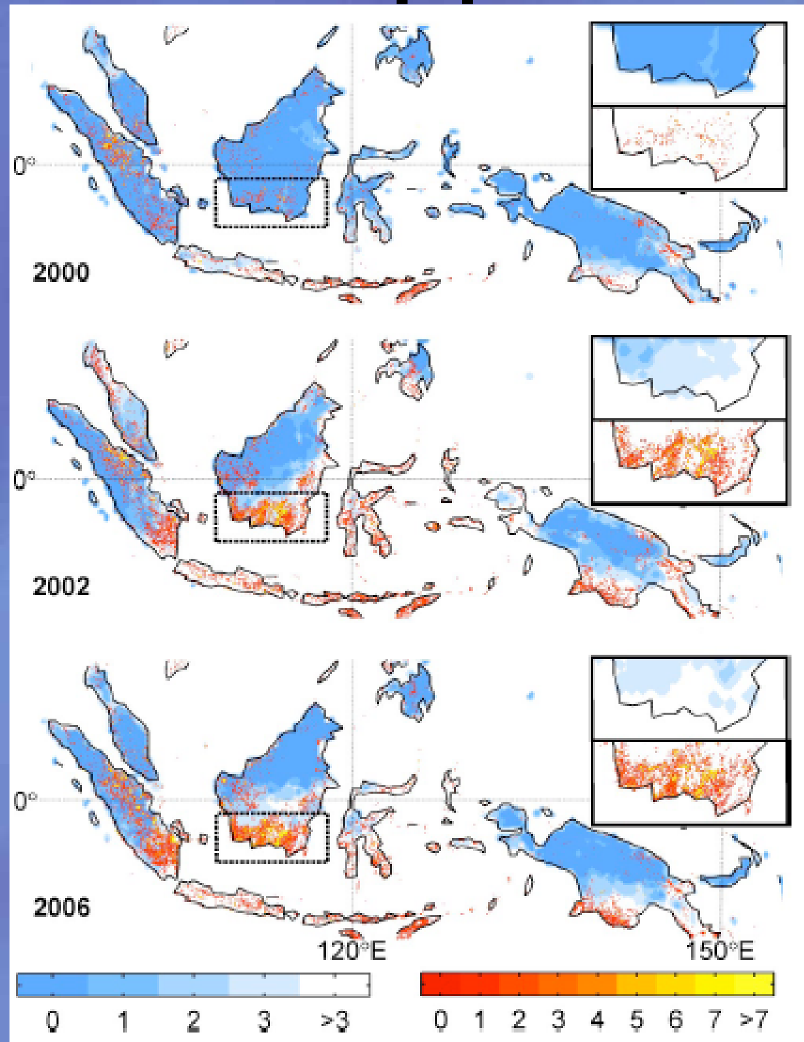
Methodology Summary. Our approach relied extensively on satellite data to (*i*) constrain fire emissions from the whole region, (*ii*) calculate annual clearing rates in southern Borneo (where interannual variability in drought was highest), and (*iii*) assess how drought based on precipitation rates from the Tropical Rainfall Measurement Mission (TRMM) (14) affected spatial patterns of fire, especially regarding their distance from drainage canals. Fire emissions estimates were available for 1997–2006 as a subset of the Global Fire Emissions Database version 2 (GFED2) based on burned area (15) and biogeochemical modeling (16) at coarse 1° × 1° resolution. To further constrain these bottom-up estimates—which are uncertain in this region with complex fuel characteristics and uncertain burned area estimates—we transported the GFED2 carbon monoxide (CO) emissions from fires and CO from other sources into the atmosphere, using the GEOS-Chem (17) chemistry transport model. This allowed for a comparison of modeled and measured atmospheric CO column mixing ratios because the latter are



2000–2006 average fire emissions

Region: 128 ± 51 Tg C yr^{-1}

Borneo: 74 ± 33 Tg C yr^{-1}

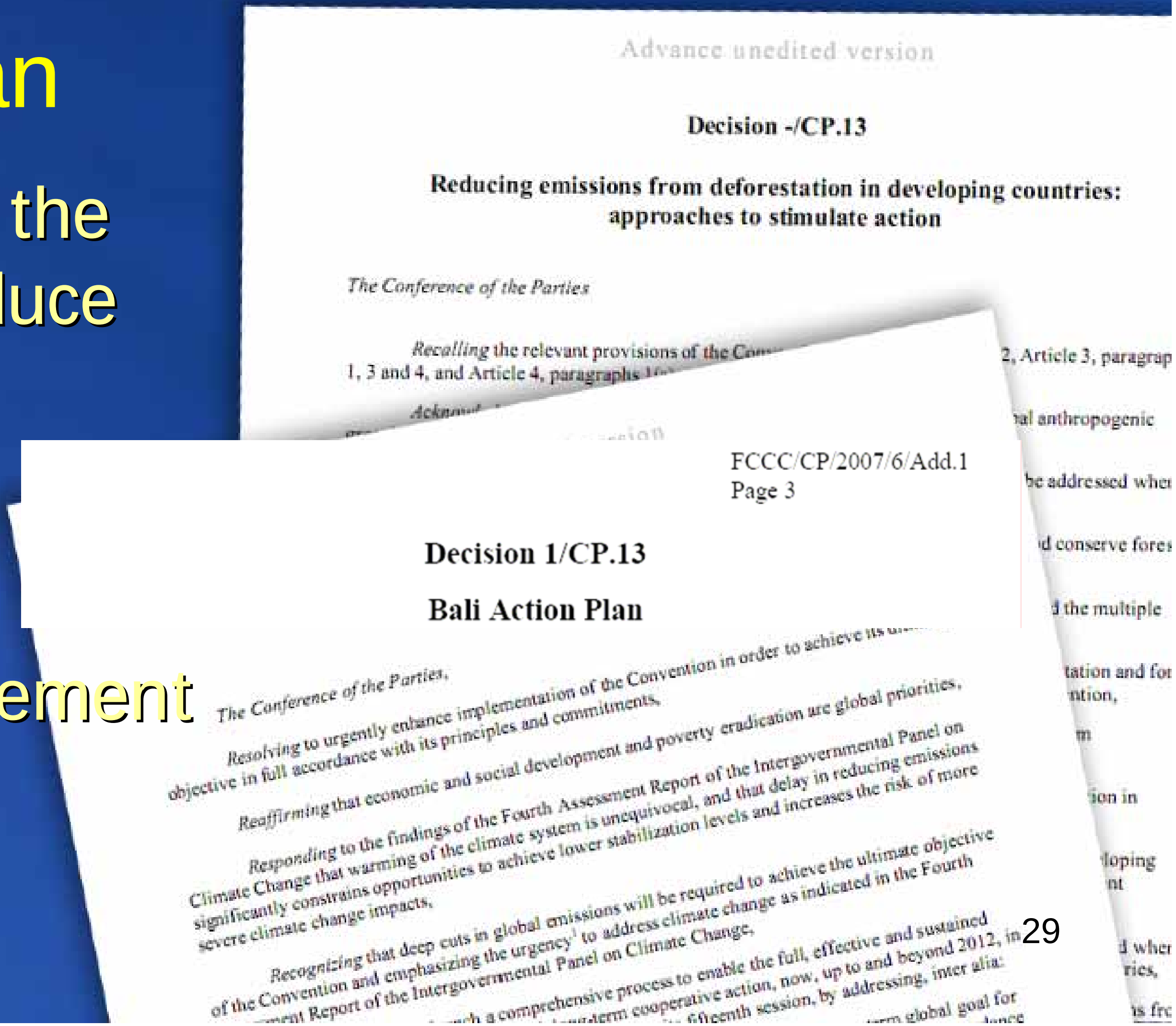


Why might REDD succeed?

- Volume of finance sufficient to shift the political economy of drivers of deforestation and degradation
- Political attention and engagement at the national level
- Alignment of the interests of multiple constituencies
- Performance-based finance

Bali Action Plan

- REDD is one of the decisions to reduce emissions
- Conservation
- SFM
- C-stock enhancement



Advance unedited version

Decision -/CP.13

Reducing emissions from deforestation in developing countries: approaches to stimulate action

The Conference of the Parties

FCCC/CP/2007/6/Add.1
Page 3

Decision 1/CP.13

Bali Action Plan

The Conference of the Parties,

Resolving to urgently enhance implementation of the Convention in order to achieve its ultimate objective in full accordance with its principles and commitments,

Reaffirming that economic and social development and poverty eradication are global priorities,

Responding to the findings of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change that warming of the climate system is unequivocal, and that delay in reducing emissions significantly constrains opportunities to achieve lower stabilization levels and increases the risk of more severe climate change impacts,

Recognizing that deep cuts in global emissions will be required to achieve the ultimate objective of the Convention and emphasizing the urgency to address climate change as indicated in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,

Potential for REDD “win-wins”

Emissions reduction and….

- Reduce poverty
- Improved livelihoods
- Conservation of biological diversity and watershed functions
- Improved forest governance

Potential risks for REDD

- Human rights violation
- Marginalize the worse-off
- Mis-use of funds
- Emission reduction effectiveness

Summary

- The vulnerability of forest ecosystems, including the dependant society to CC may be assessed
- There is a need to test C&I for the ecosystems vulnerability to climate change
- Field and remotely sensed data are crucial for adaptation (and mitigation) strategies
- Enhancing the role of forests for climate change mitigation (REDD) could be used as entry point to reduce ecosystem vulnerability