3E (energy-environment-ecosystem) + 1 (economy) nexus:

Conserving mangrove forests for better human resilience, food security, and carbon sequestration to offset climate change

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1. Introduction: Mitigating and Resilience thinking

Issues

Global warming

Climate/ecosystem change

Disasters

Hunger

Undernourished

Developing nations

How?

Sustainable development

Resilience of socio-ecological systems

Food security

Reducing vulnerability

Implementing

offsetting

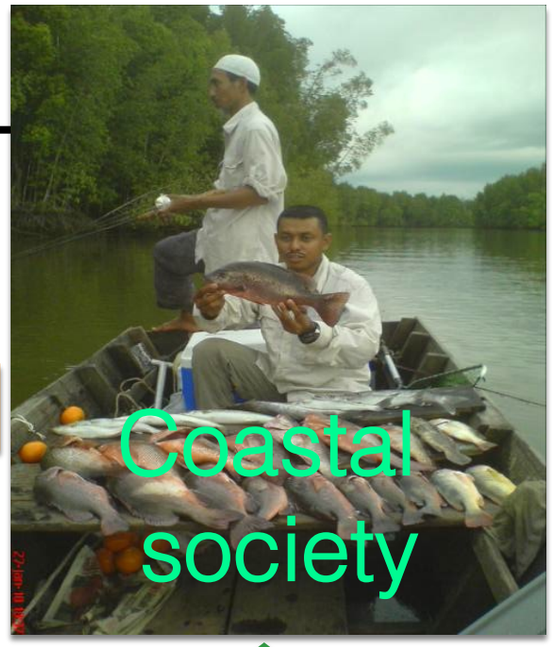
Increasing

Sustainable use and Conservation of coastal ecosystems and natural resources

(E.g., mangroves; seagrass; coral reefs)

Enhancing resilience and food security for SD

1. Introduction: Resilient mangrove forest & coastal society



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Climate/ ecosystem change

Disasters

Ecosystem functions

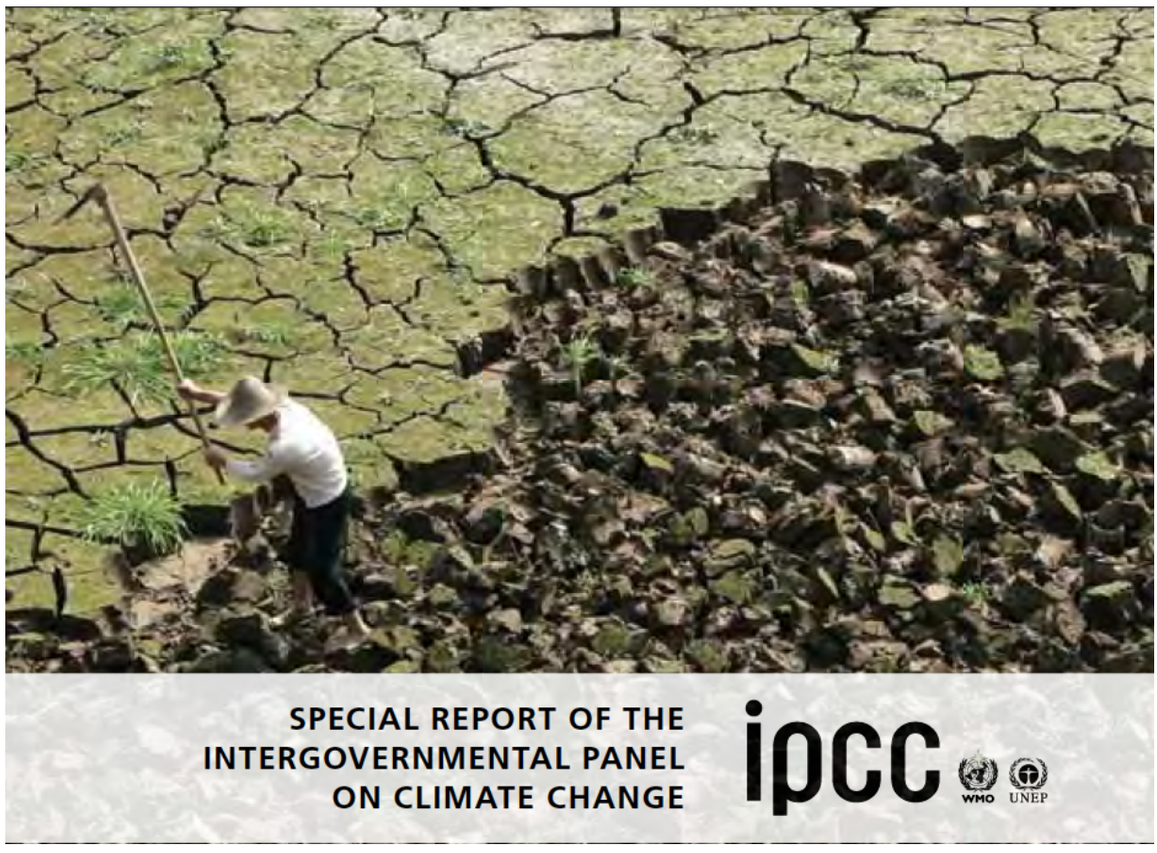
Benefits & services

- Timbers & biofuels
- Fisheries productivity
- Medicines
- Tourisms
- Disasters mitigation
- Offset greenhouse emissions

(-) negative impact
(+) positive impact

1.Introduction- Climate change:
faster than previous thought!

- Warming of the climate system is unequivocal
  - Increasing concentrations of greenhouse gases
  - Warming atmosphere and ocean
  - Diminishing snow and ice
  - Rising sea level
  - Increasing extreme weather events and disasters

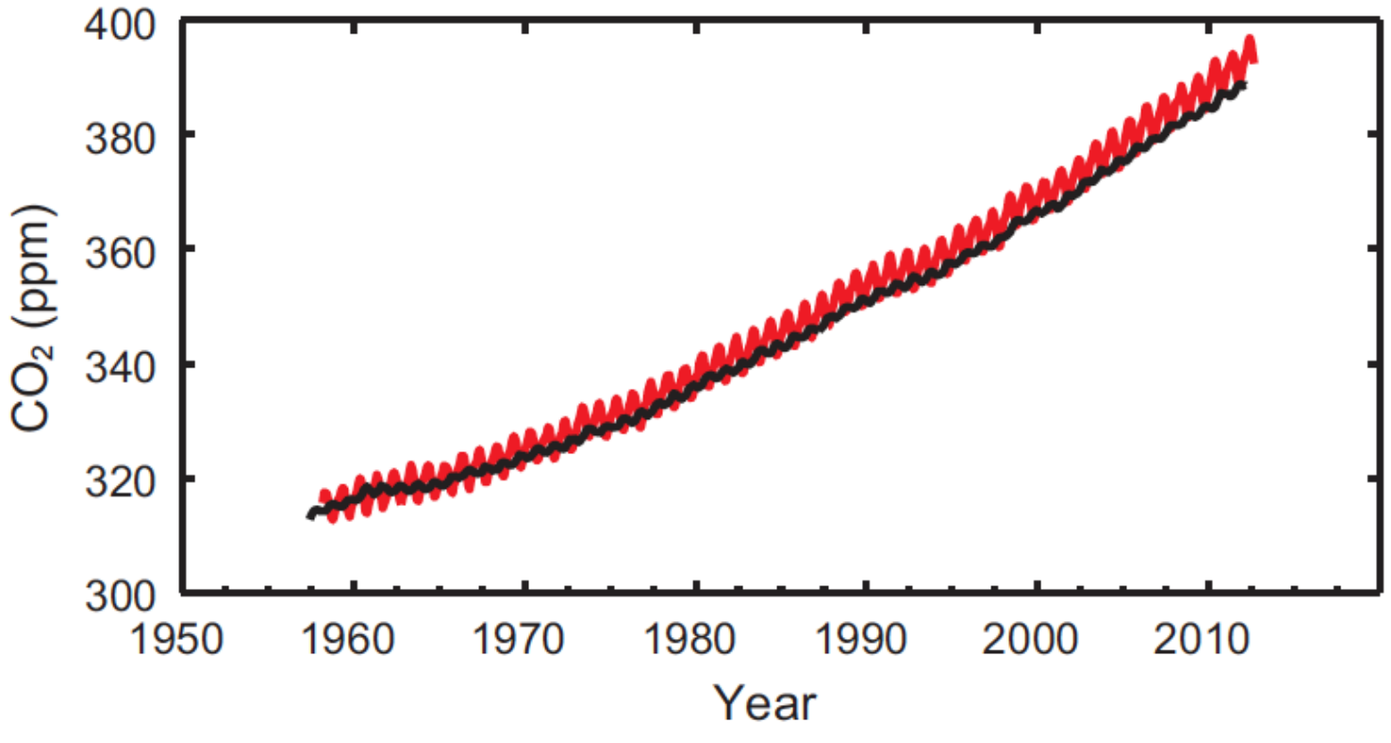


IPCC, 2013

1.Introduction- Climate change:
faster than previous thought

- Warming of the climate system is unequivocal

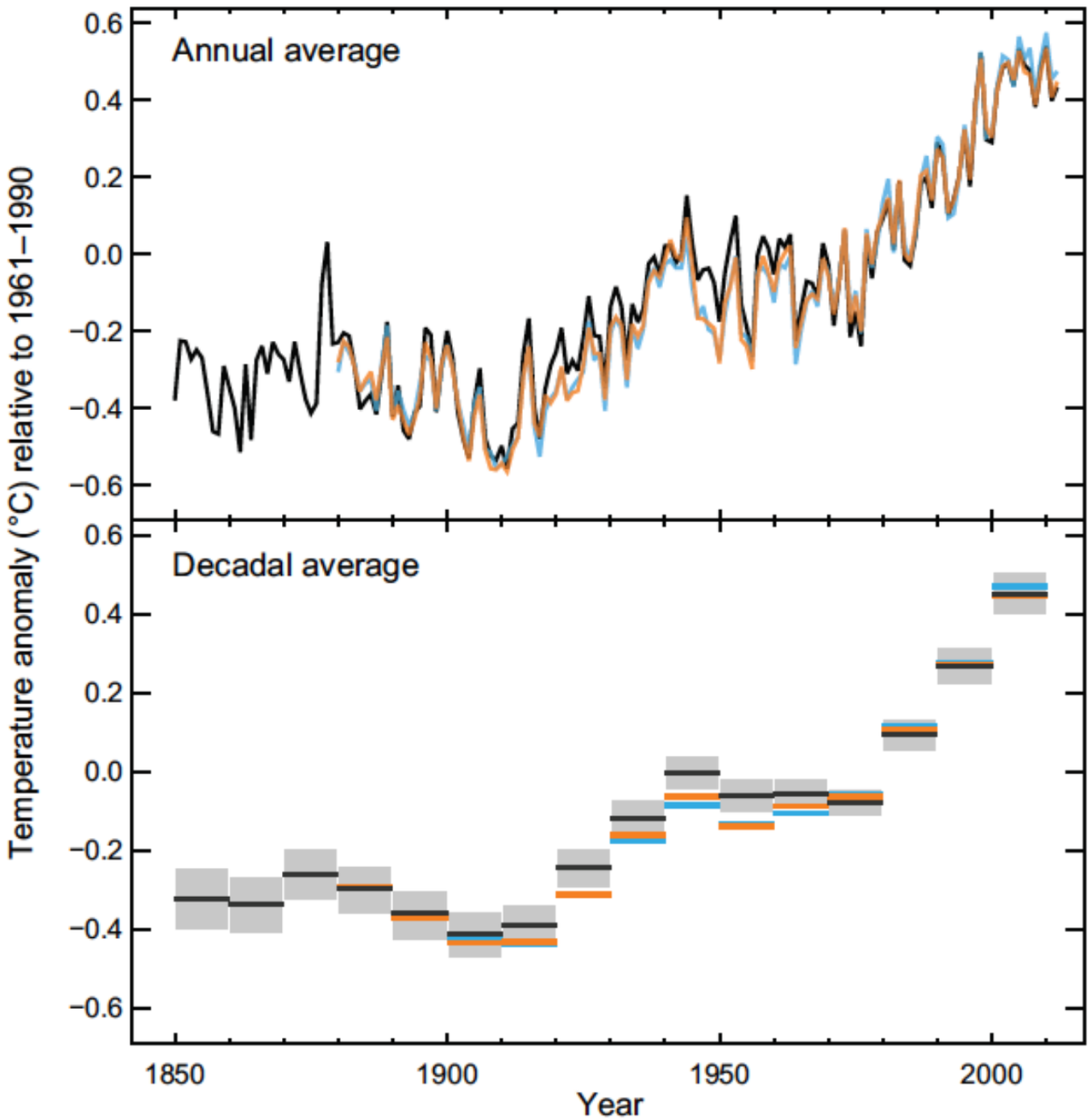
Increasing greenhouse gases emissions

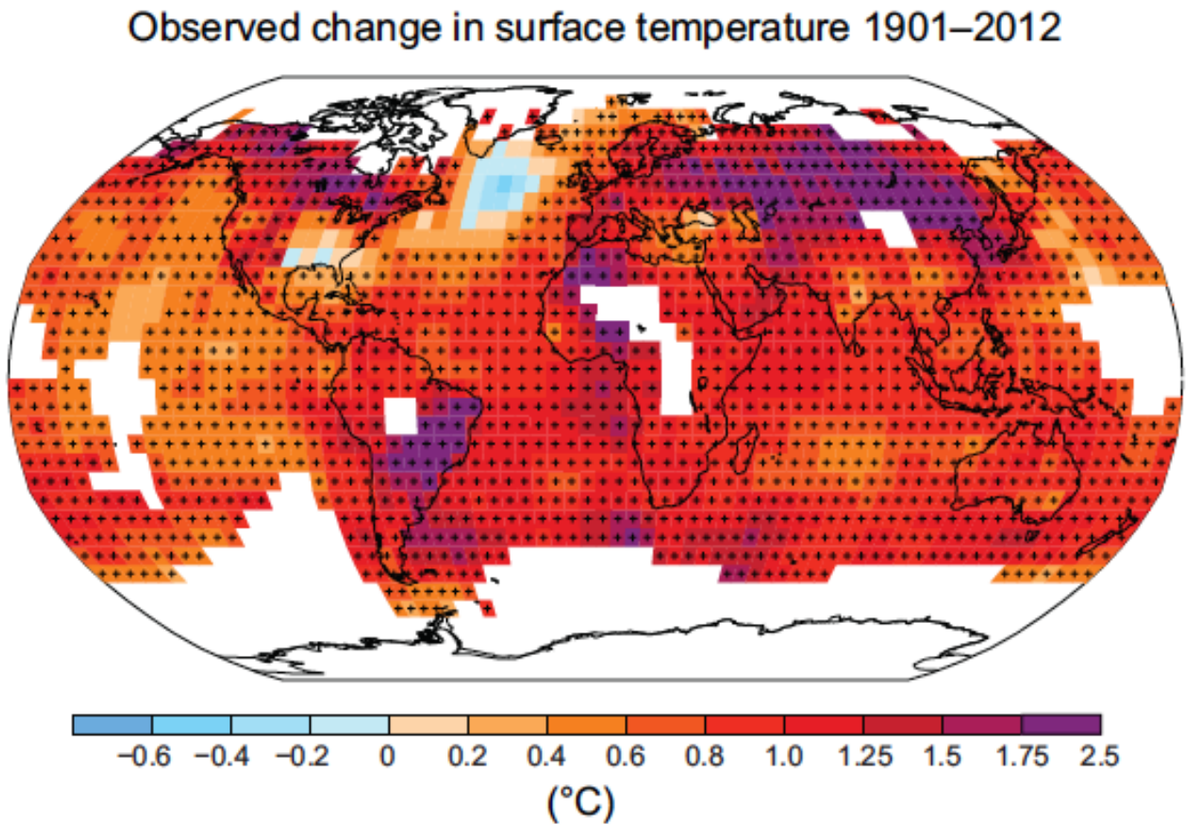


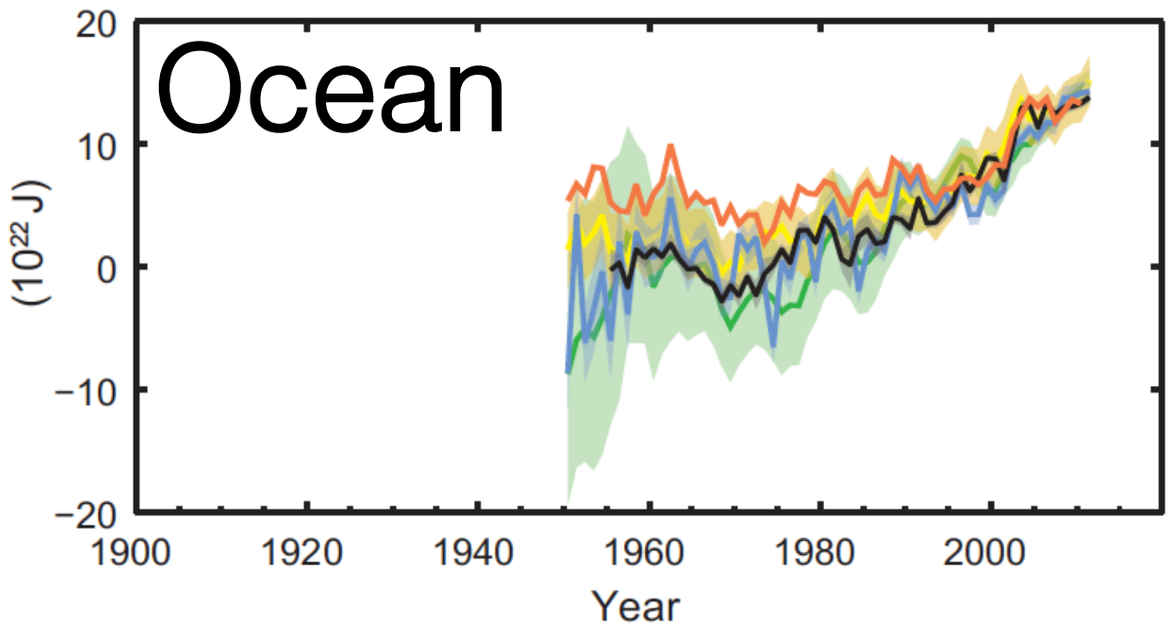
IPCC, 2013

Increasing surface temperature

Atmosphere

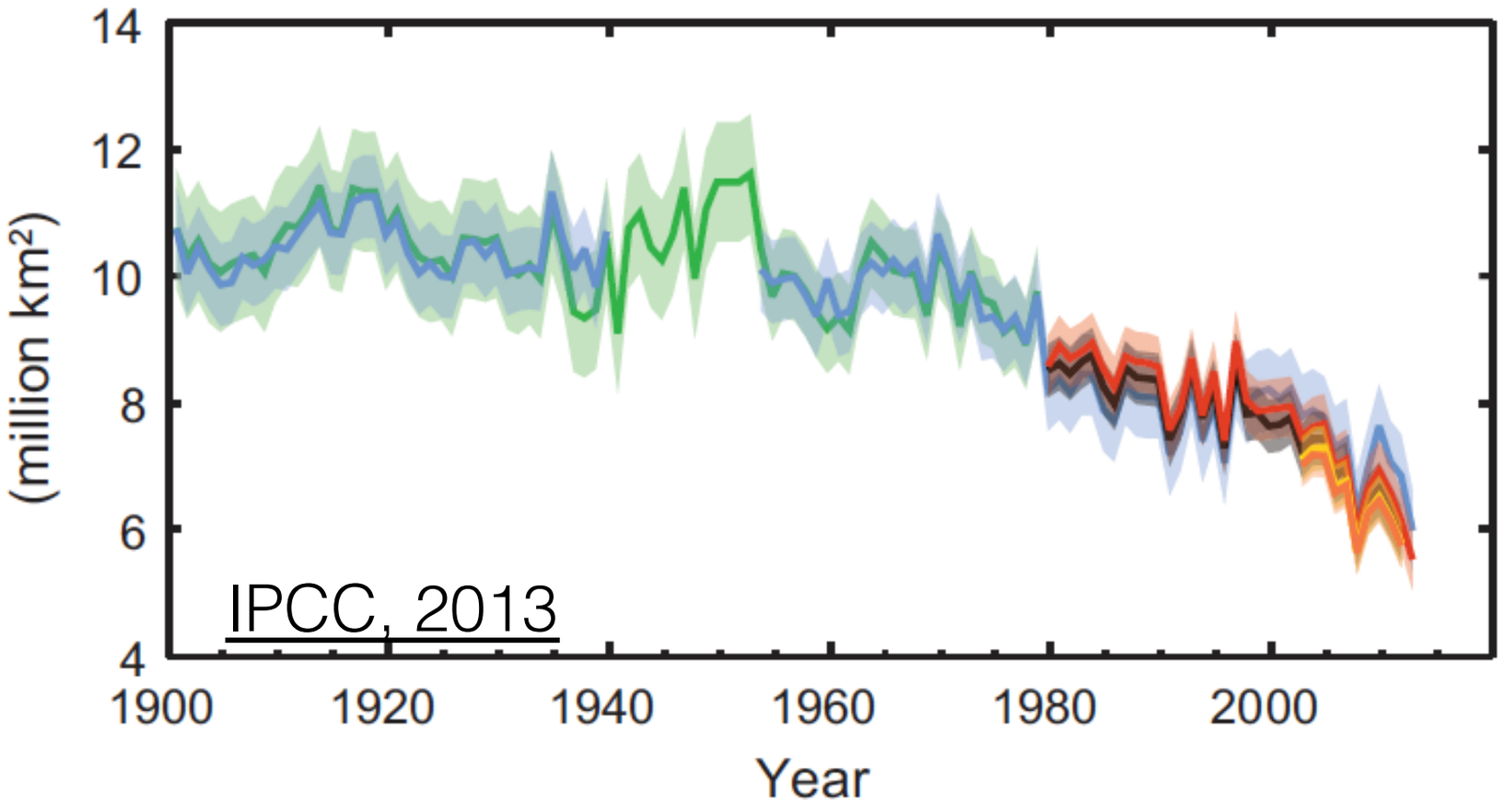






IPCC, 2013

Diminishing snow and ice

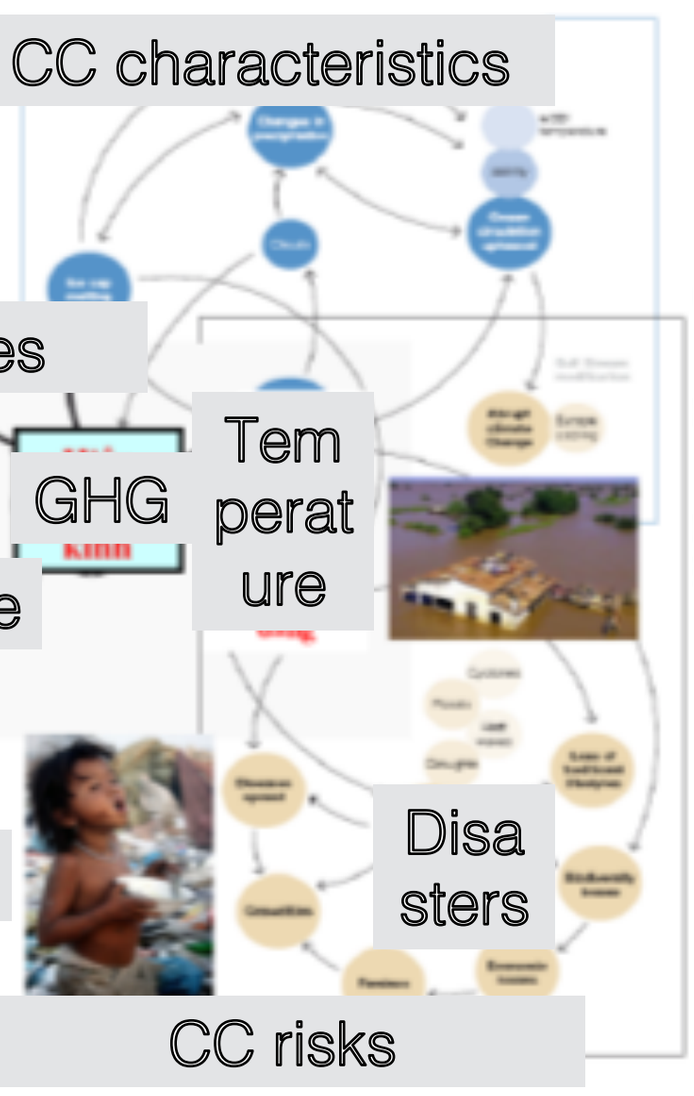


CC IMPACT IN THE WORLD

CC: processes and damages

CC characteristics

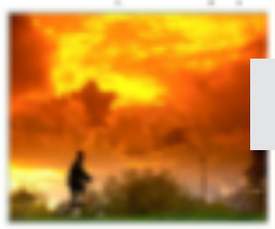
CC processes



GHG

Tem perat ure

Land use change



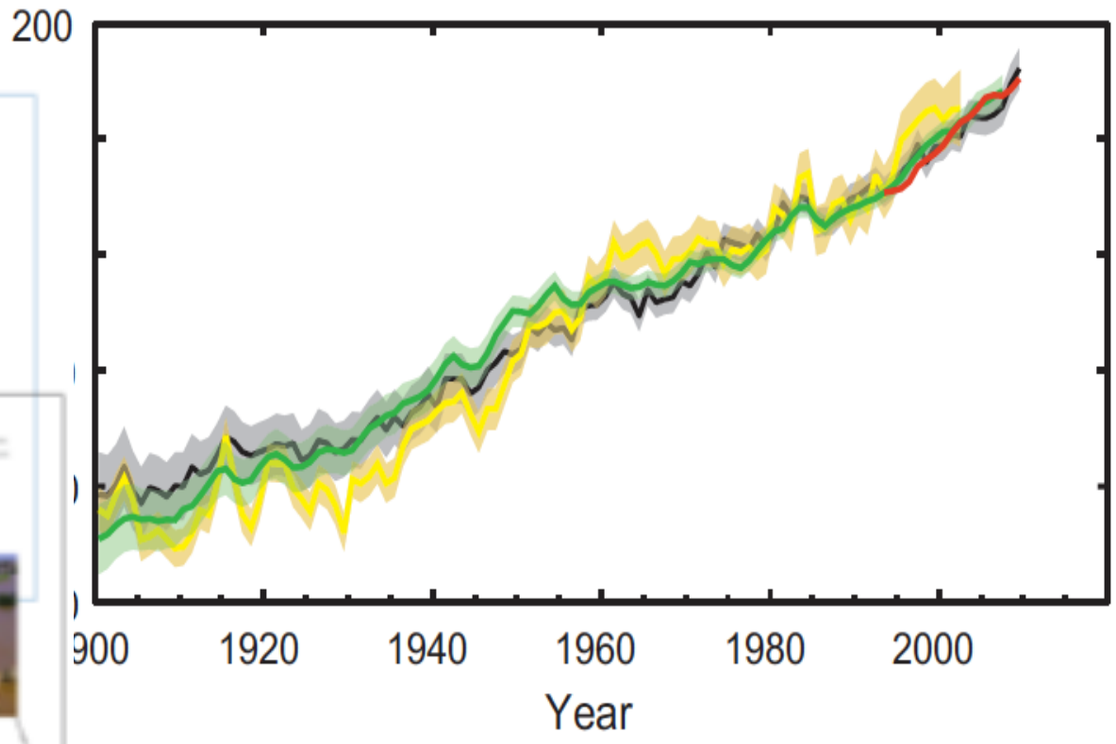
Fossil energy

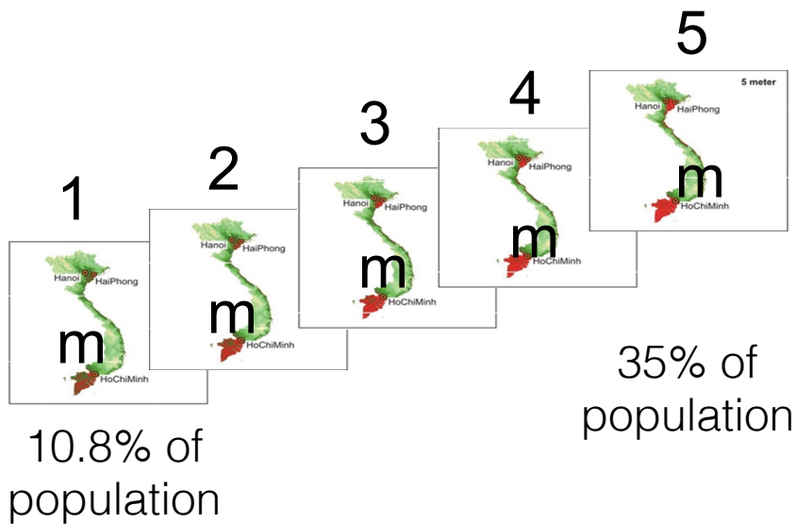
Disa sters

Human activities

CC risks

Rising sea level





10.8% of population

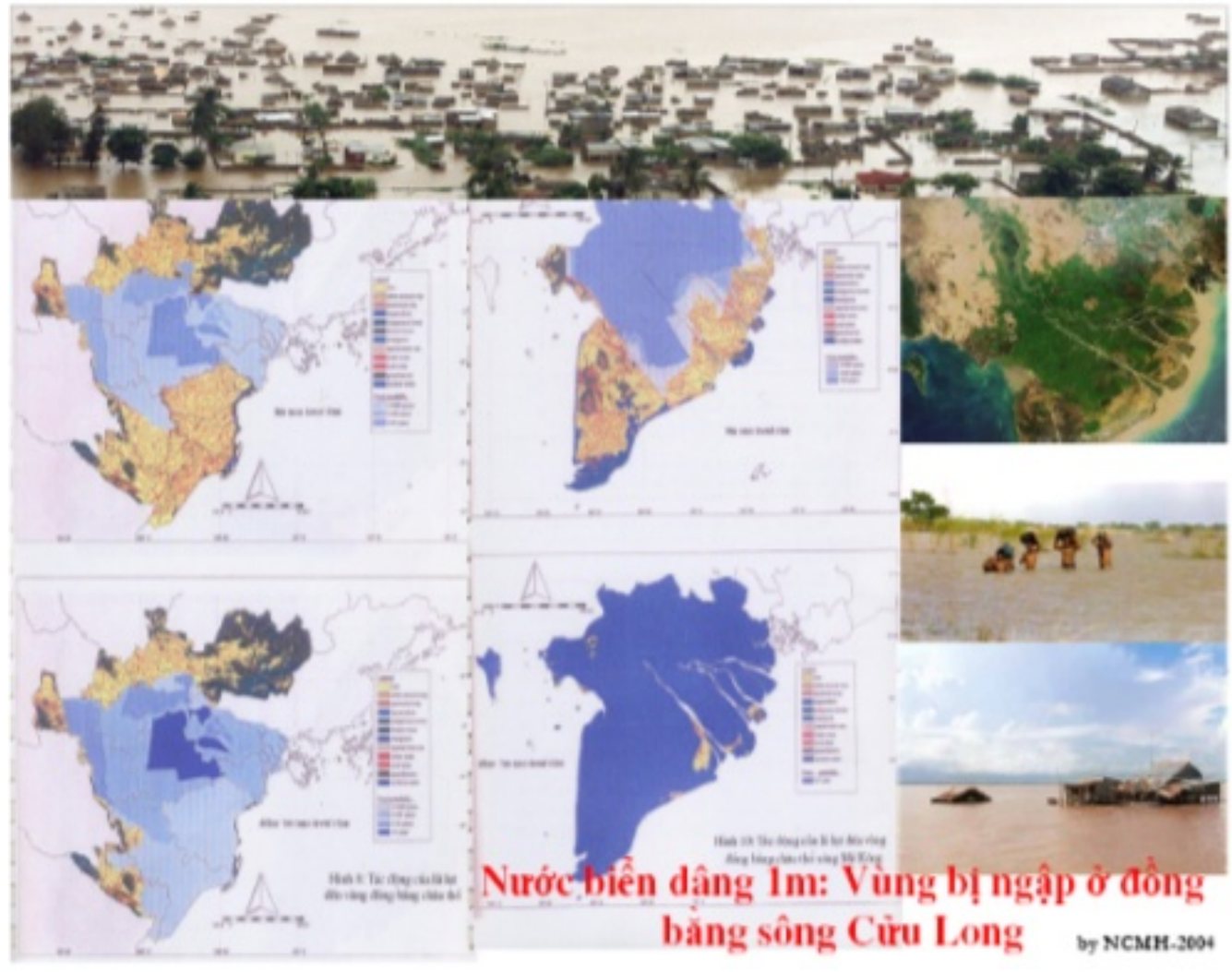
35% of population

IPCC, 2013

2.1CC IMPACT IN THE WORLD

Impact of 1m of SLR in the SEA and Australia

…and in Mekong delta, VN

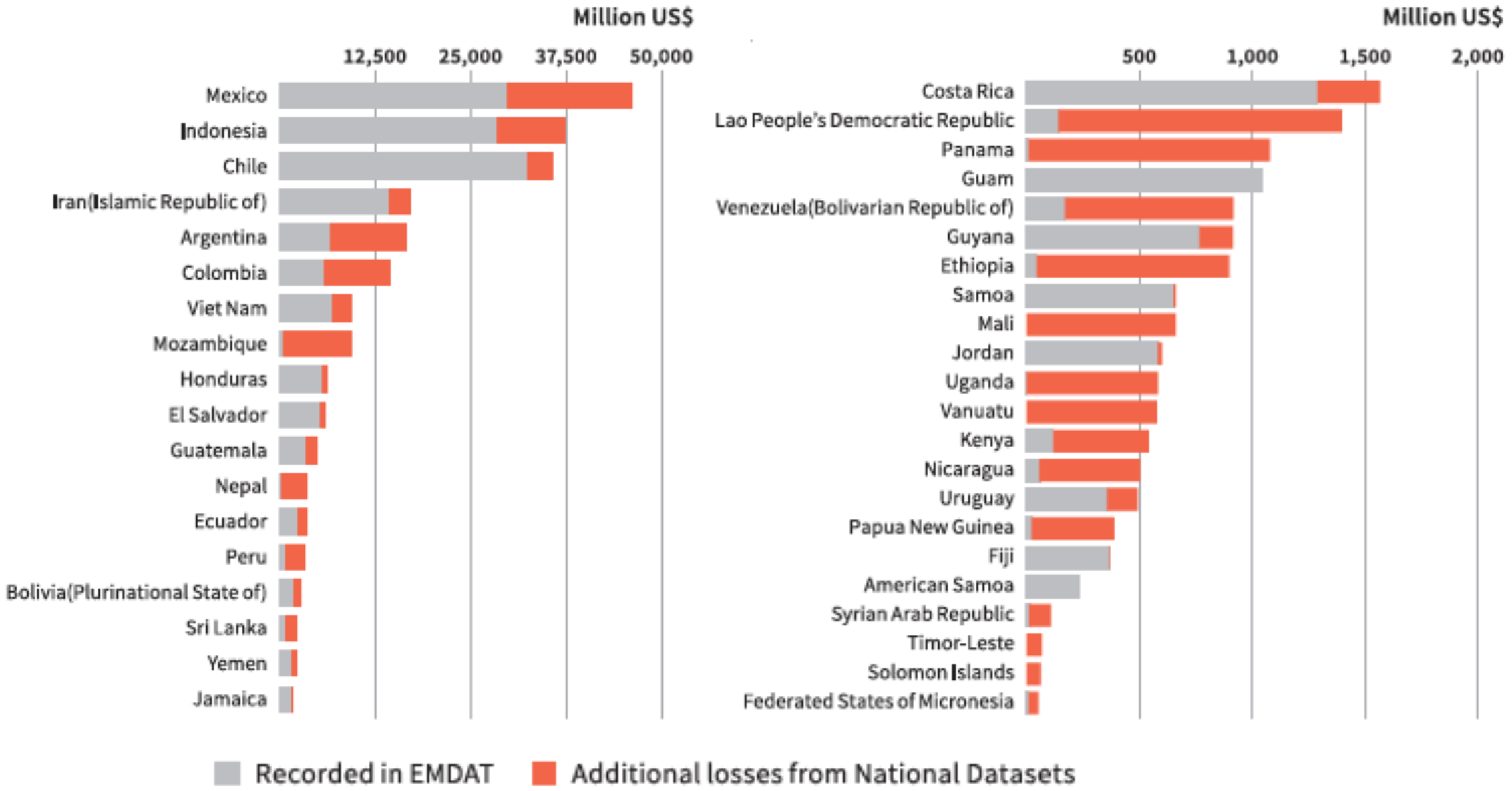


…inundated area :347,680 km2

Population impacted:46,683,288

Disasters

Direct economic losses in 40 countries as estimated from national and global loss databases, 1981–2011 (in million US$)



Extreme loss in developing countries and small islands

UNISDR, 2013

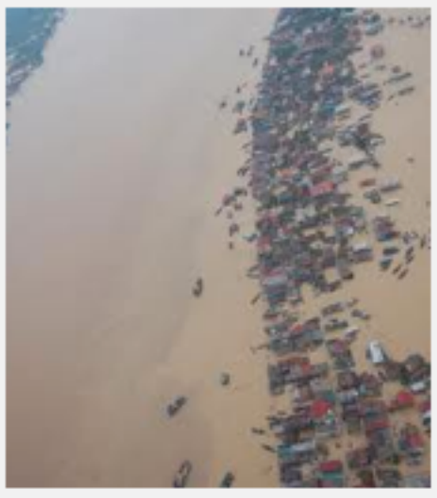
Disasters

Devastation in the aftermath of Typhoon Haiyan on November 13 in Tacloban, Leyte, Philippines

Disasters









Flood and storm hazards in coastal zone of Vietnam in 2013

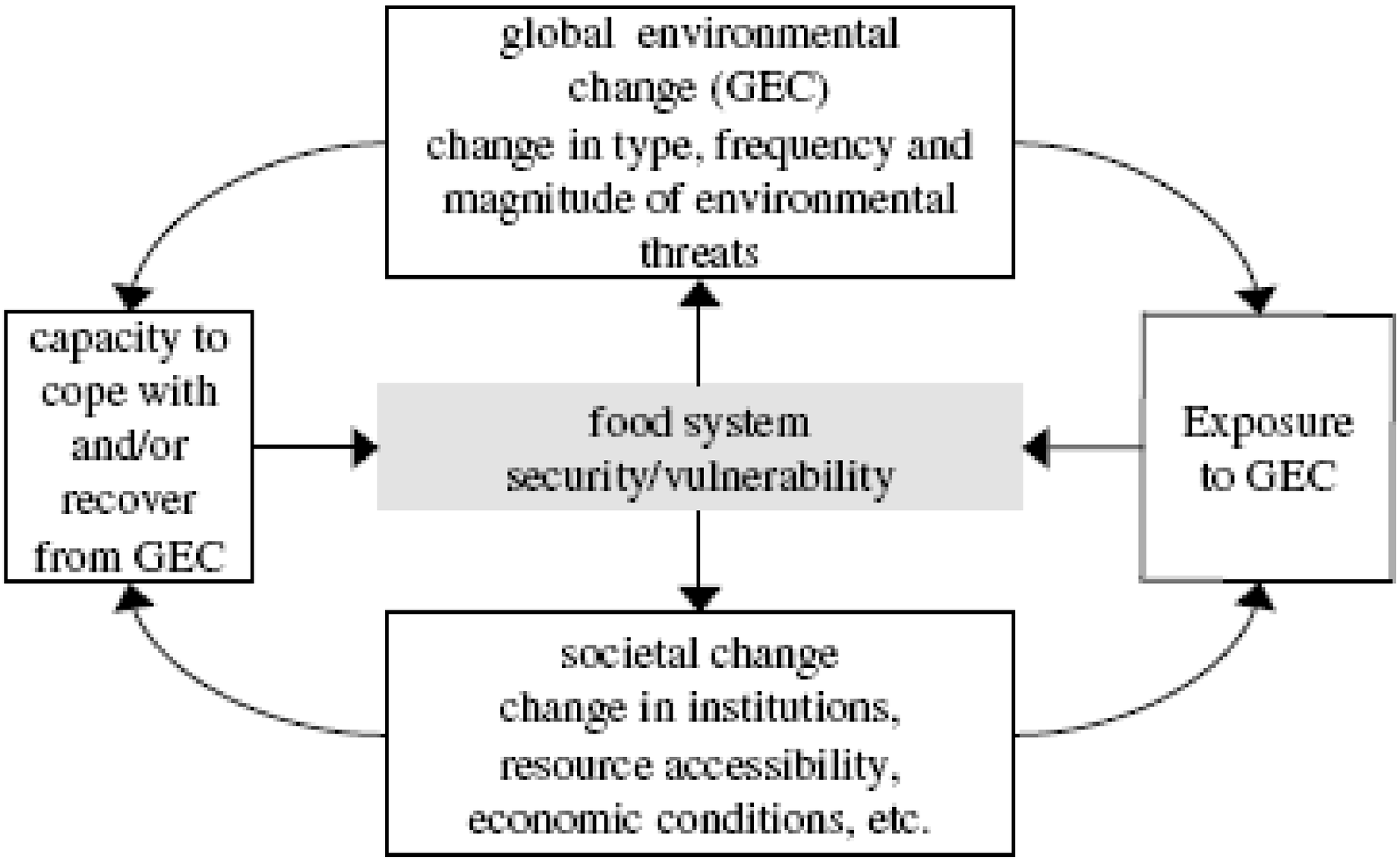
CC IMPACT IN THE WORLD

Domino Effect of Land Loss caused by Climate Change And Community Sustainability

Source: Natural Hazard Center 2006

CC IMPACT IN THE WORLD

Impact of climate change on Food Security



Factors determining the vulnerability of food systems to GEC. (From Ingram et al. 2005.)

Food security

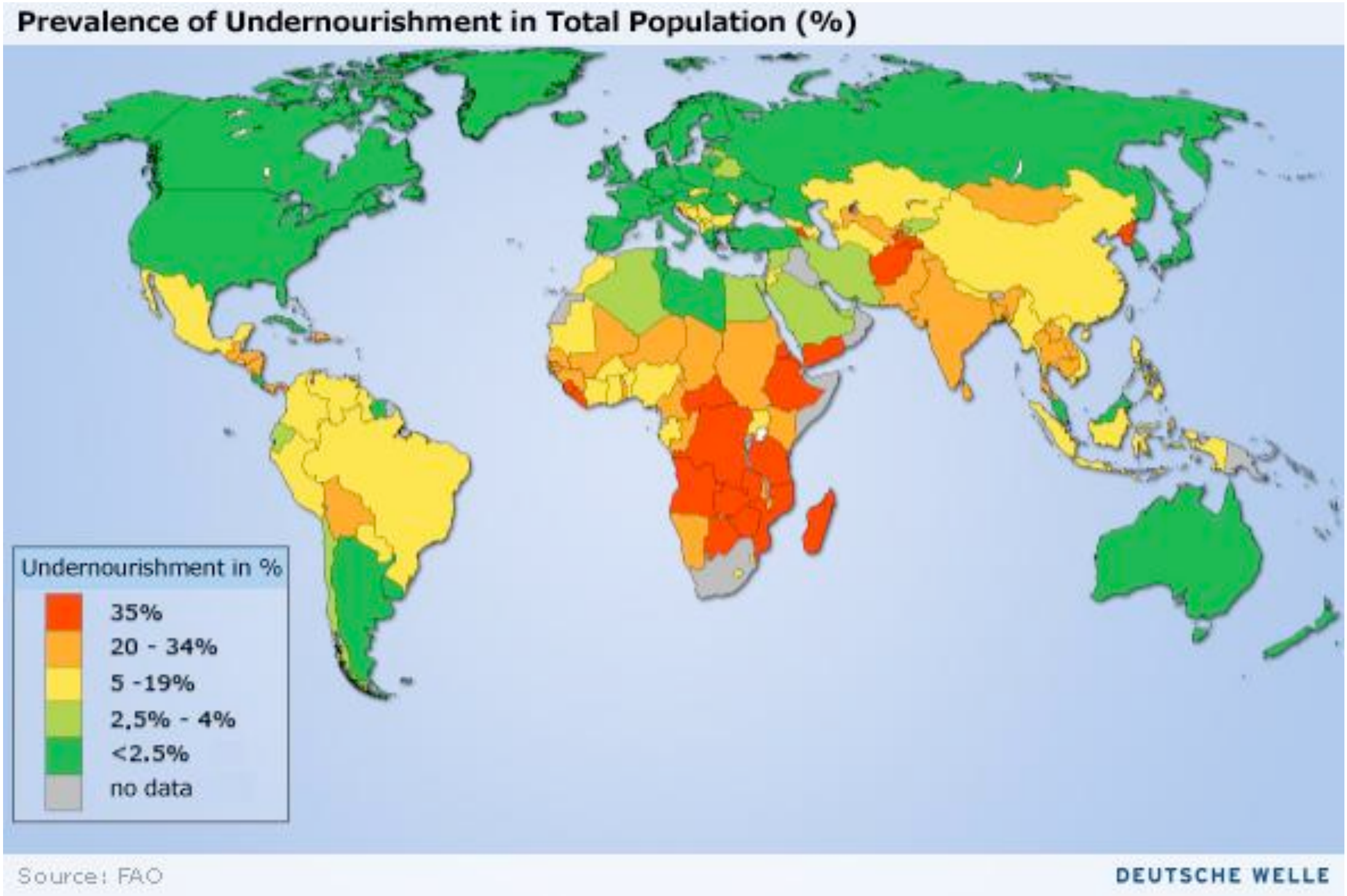
Food security exists when all people, at all times, have physical and economic access to sufficient, safe, nutritious and culturally appropriate food to meet their dietary needs and food preferences for an active and healthy life *(World Food Summit 1996)*.

The suite of food security indicators

FOOD SECURITY INDICATORS	DIMENSION
Average dietary energy supply adequacy Average value of food production Share of dietary energy supply derived from cereals, roots and tubers Average protein supply Average supply of protein of animal origin	AVAILABILITY
Percentage of paved roads over total roads Road density Rail lines density	PHYSICAL ACCESS
Domestic food price index	ECONOMIC ACCESS
Access to improved water sources Access to improved sanitation facilities	UTILIZATION
Cereal import dependency ratio Percentage of arable land equipped for irrigation Value of food imports over total merchandise exports	VULNERABILITY
Political stability and absence of violence/terrorism Domestic food price volatility Per capita food production variability Per capita food supply variability	SHOCKS

FAO, 2013

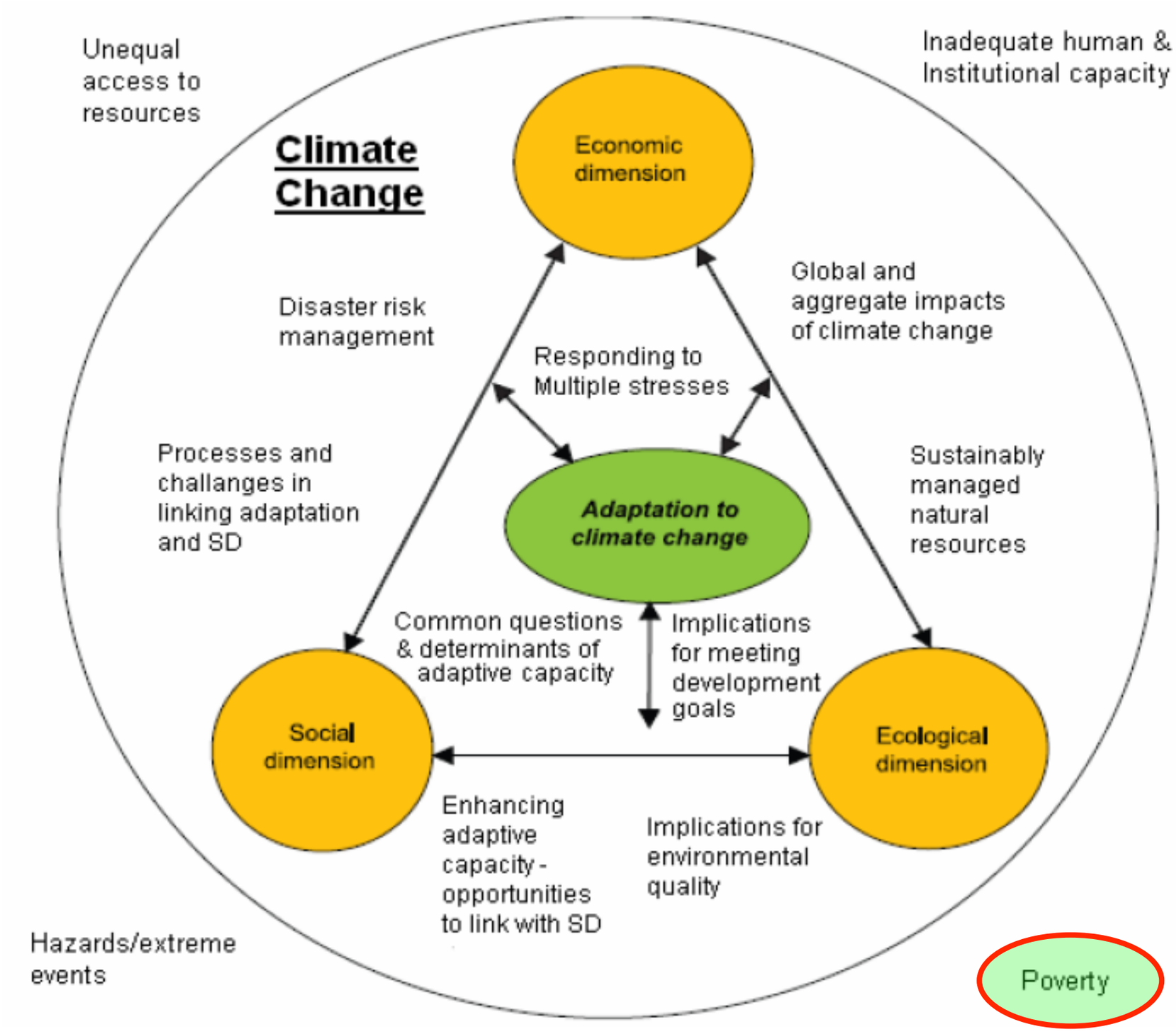
Food security



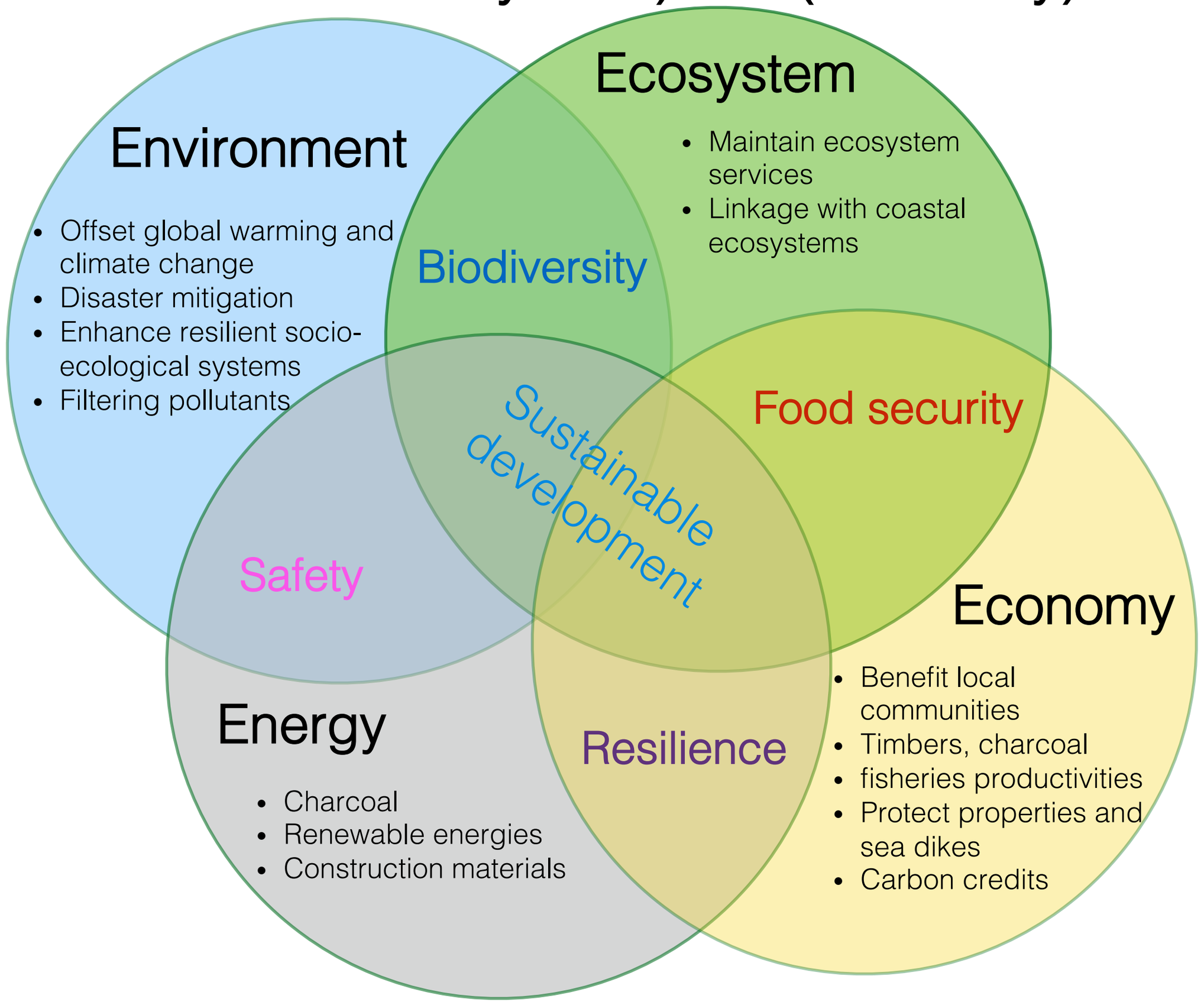
Highest undernourishment in tropical regions?

CC IMPACT IN THE WORLD

Issues & Challenges on building resilience & capacity of Climate Change approaching Sustainable Development

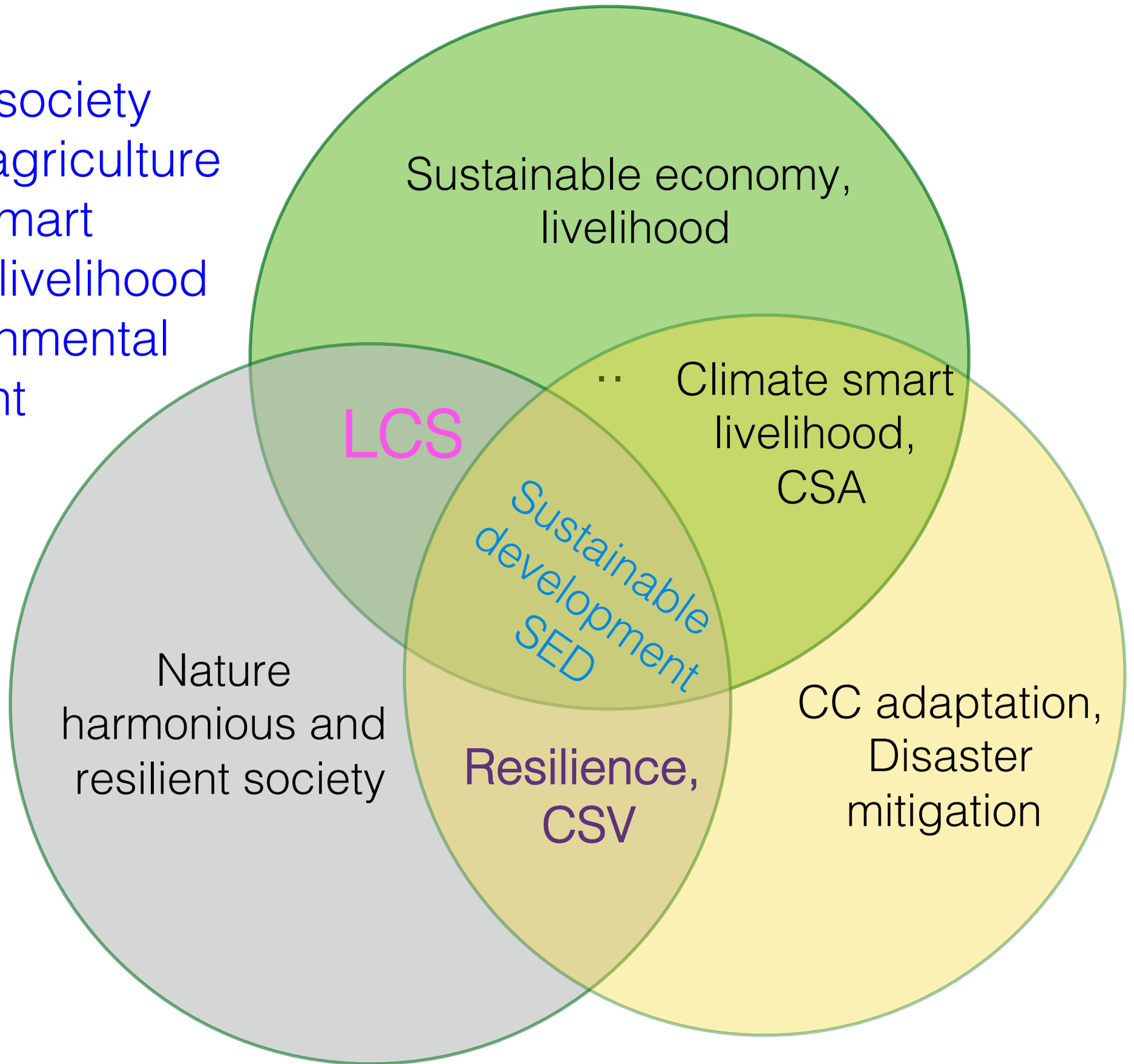


1. Introduction: Mangrove ecosystem = 3E (energy +environment +ecosystem) + 1 (economy) nexus

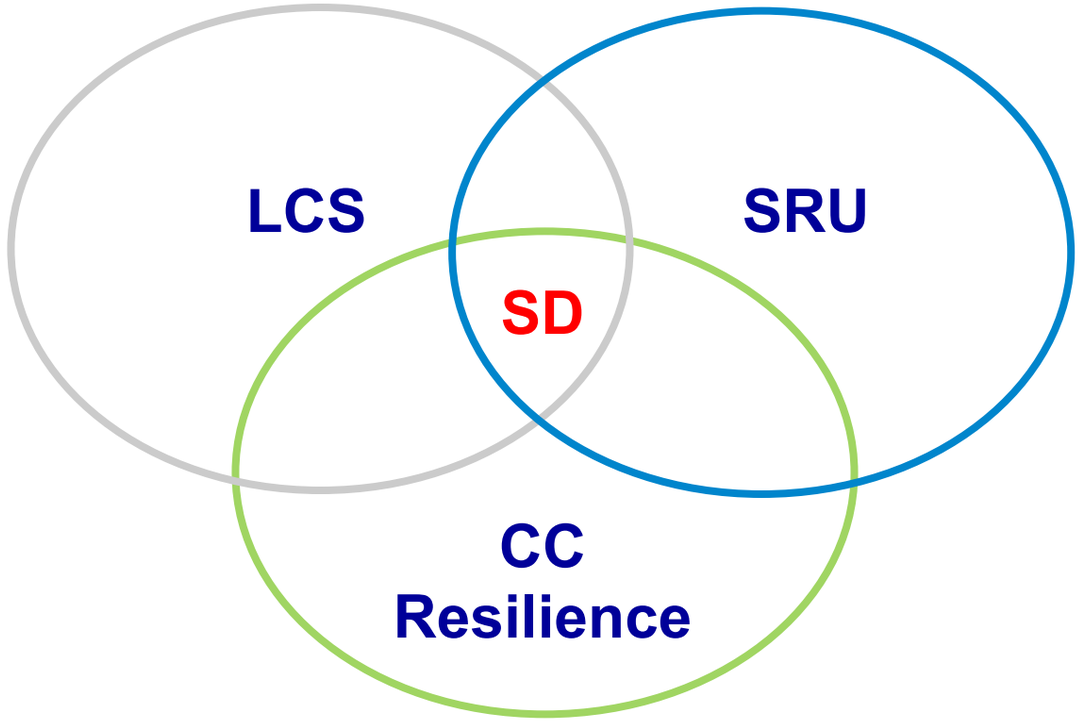


1. Sustainable development in the Global Change context

- LCS: low carbon society
- CSA: climate smart agriculture
- CSV: climate smart
- CSL: Climate smart livelihood
- SED: sound environmental development



SD based on LCS, SRU and CC resilience

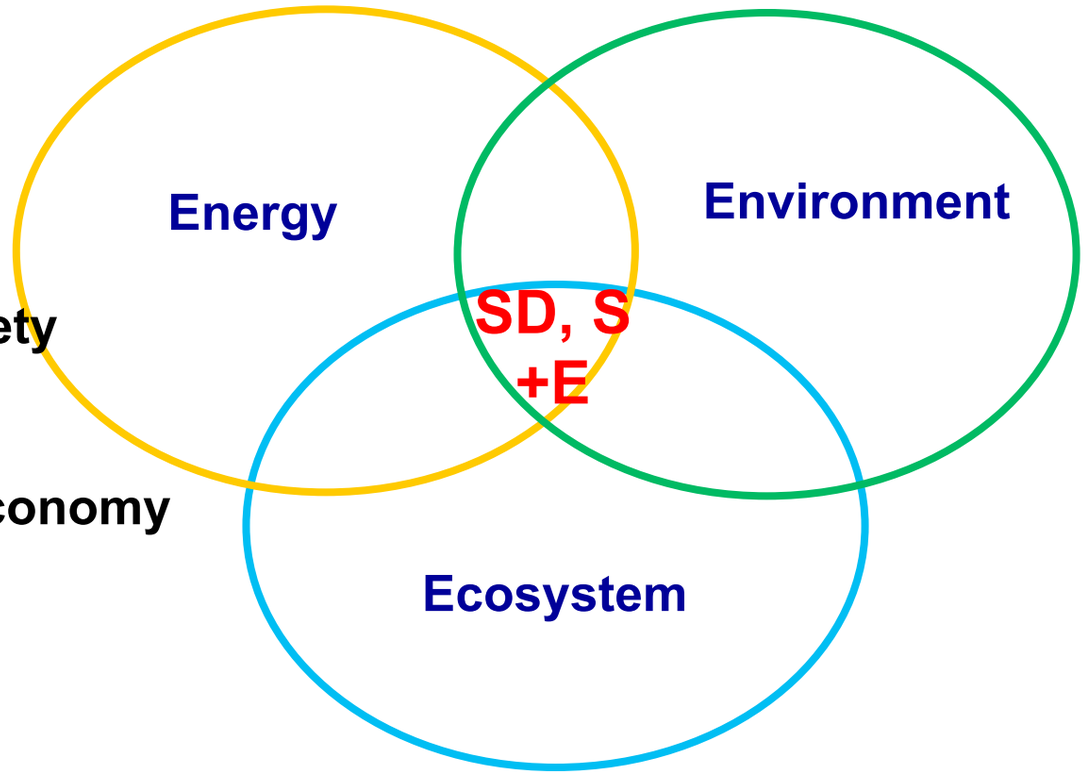


3D+1 BASED DEVELOPMENT

LCS - Low Carbon Society

S - Sustainability

E - Sustainable and green Economy



Green Livelihood

Green livelihood (UNEP)

Work

- Manufacturing Agriculture
- Research and develop
- Administrative operation
- Service

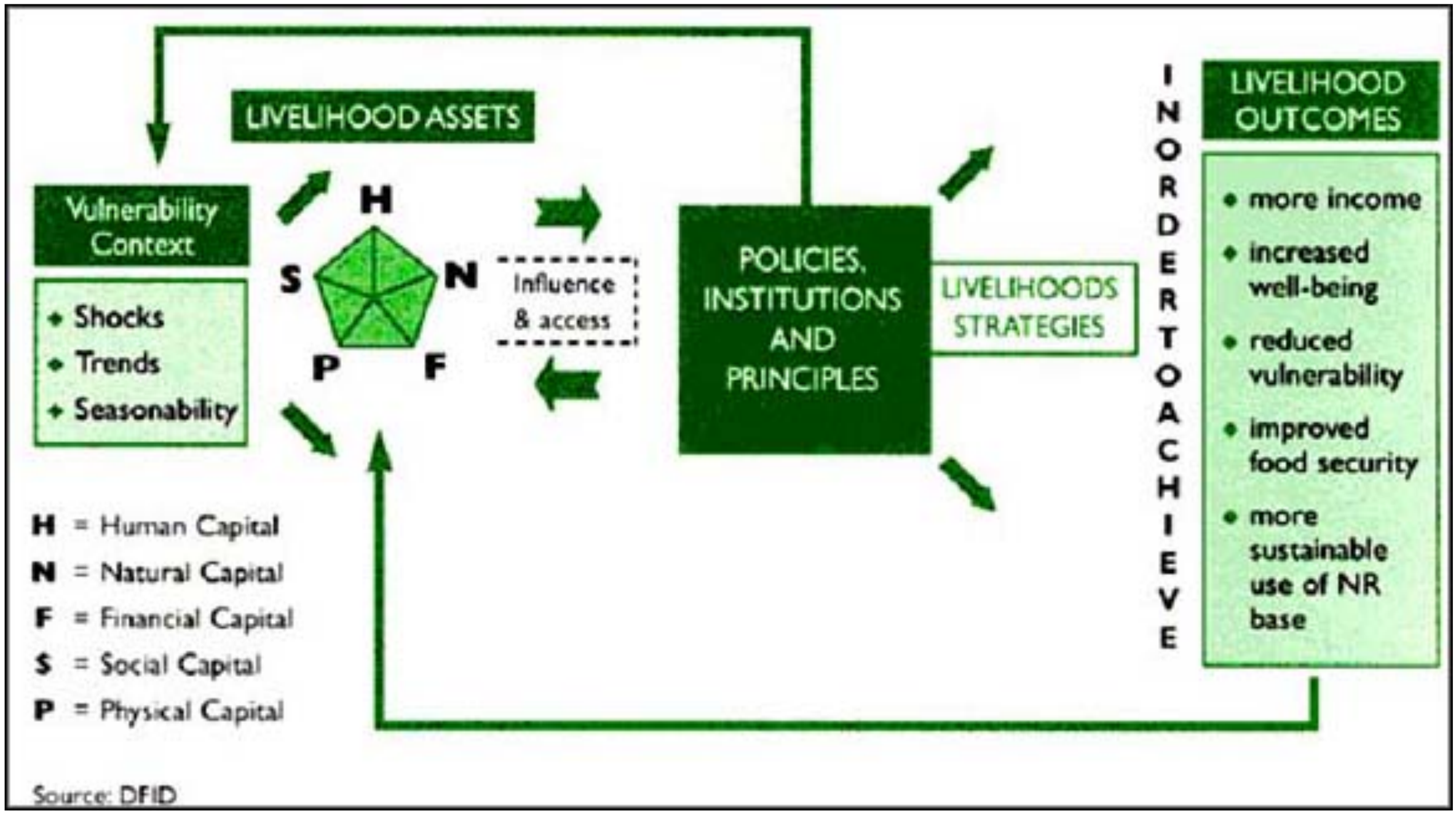
Contrib ute

Conserve, restore environment quality

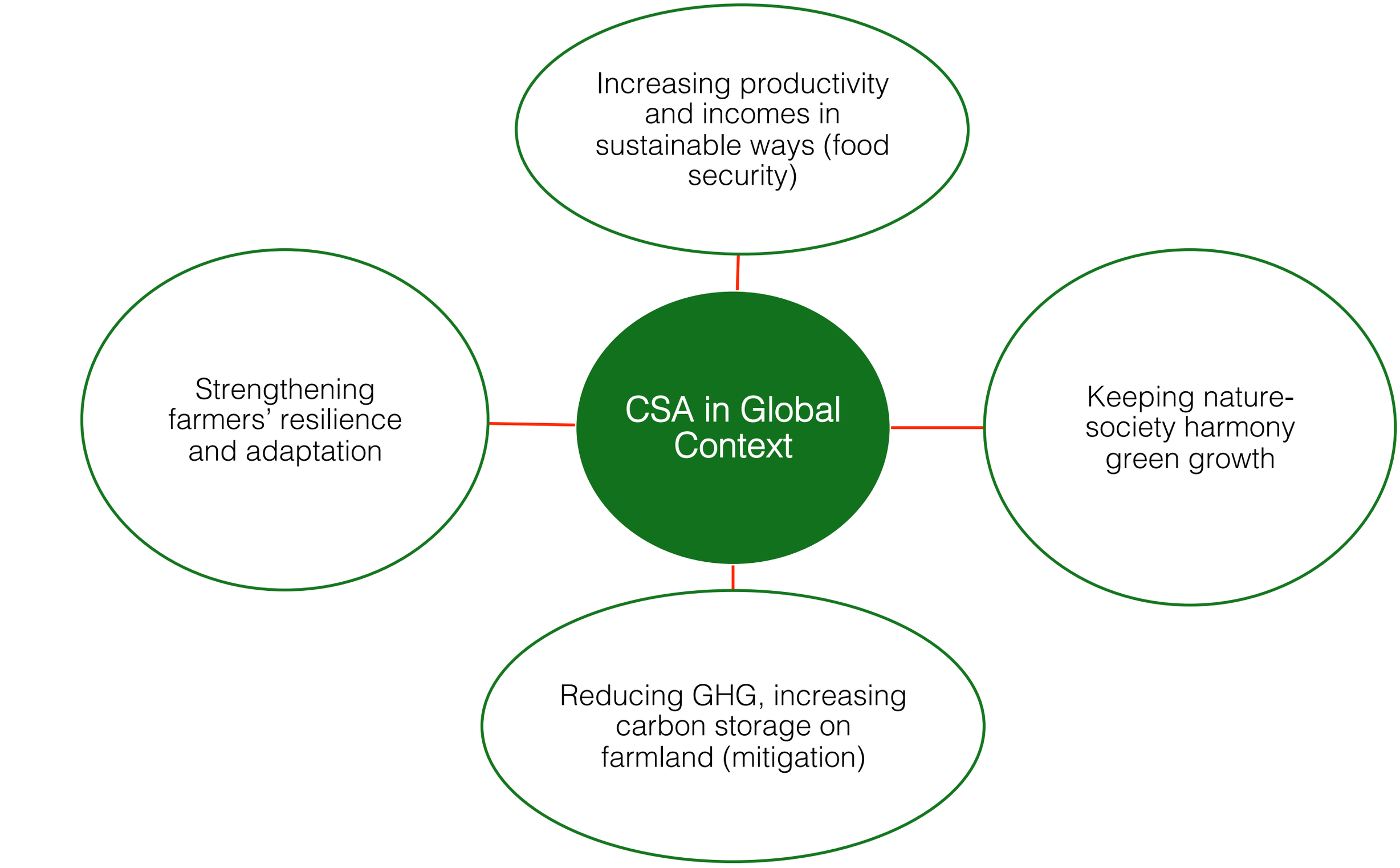
- Protect ecosystem and biodiversity
- Reduce assumption of energy and materials, water
- Reduce emission of Carbon for economics
- Reduce and avoid all of waste, pollution

Green Livelihood

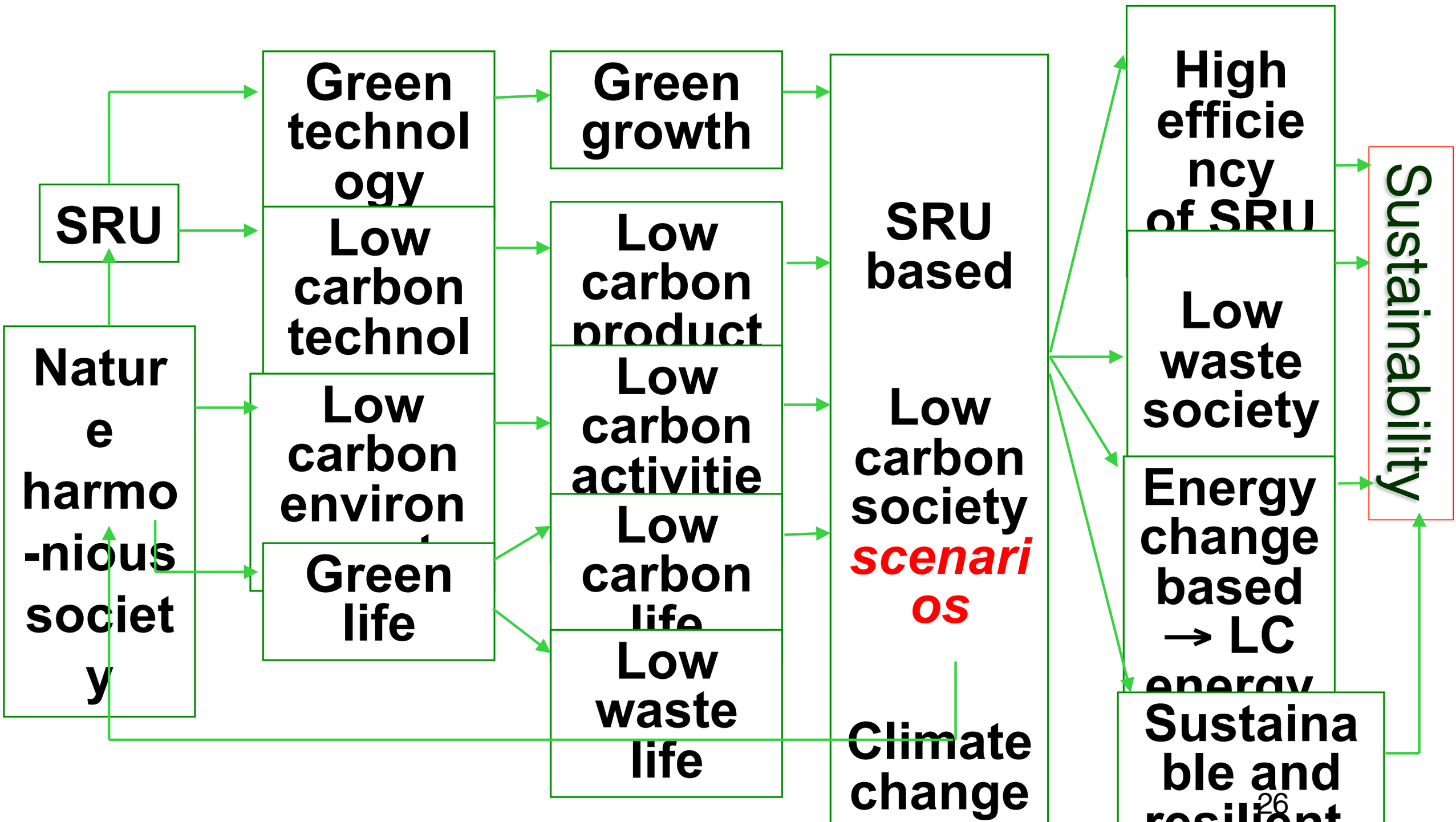
- **Sustainable livelihood: maintaining improving nature-harmony society**



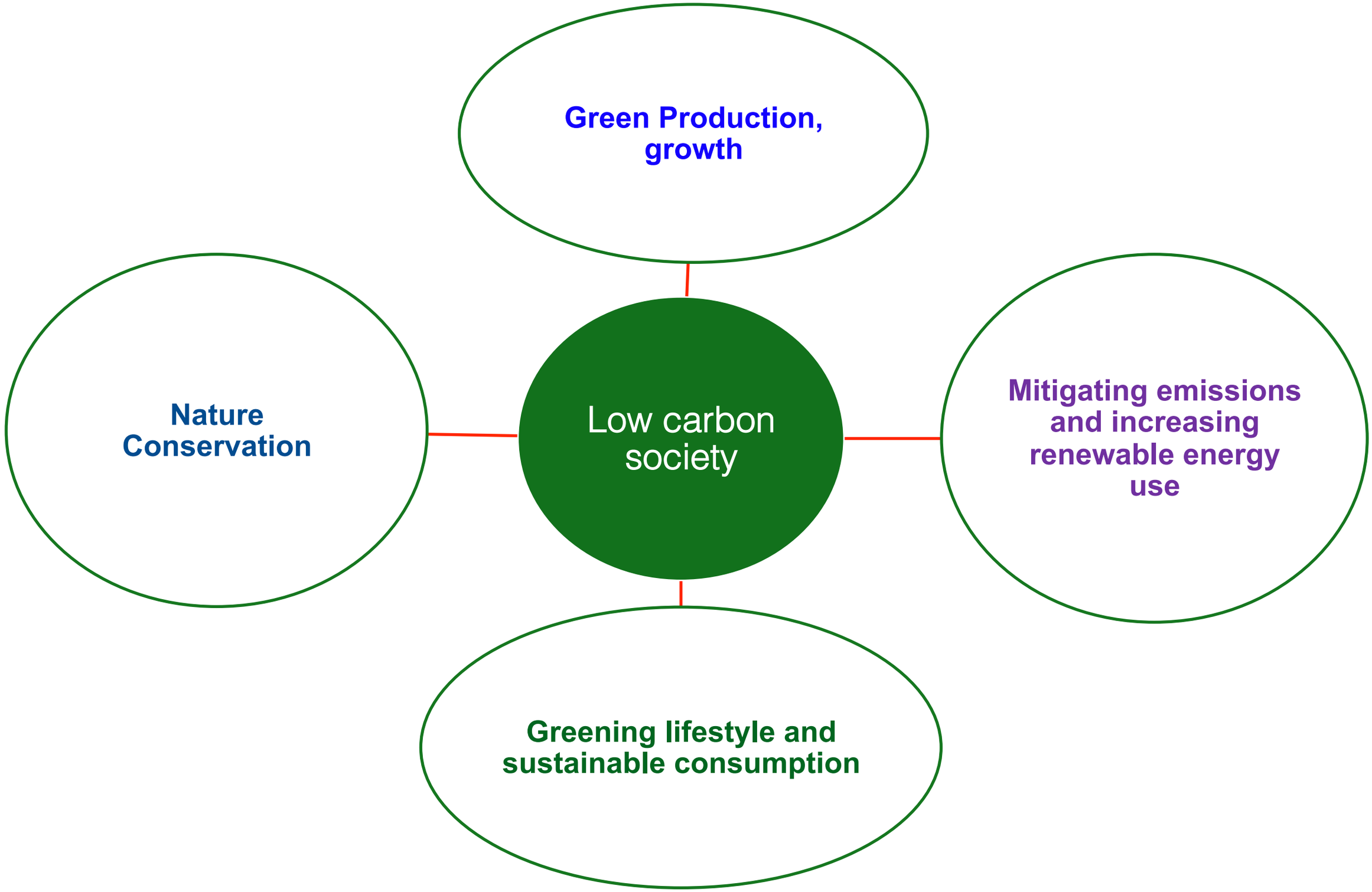
Sustainable and climate smart livelihood: Climate smart agriculture (CSA)



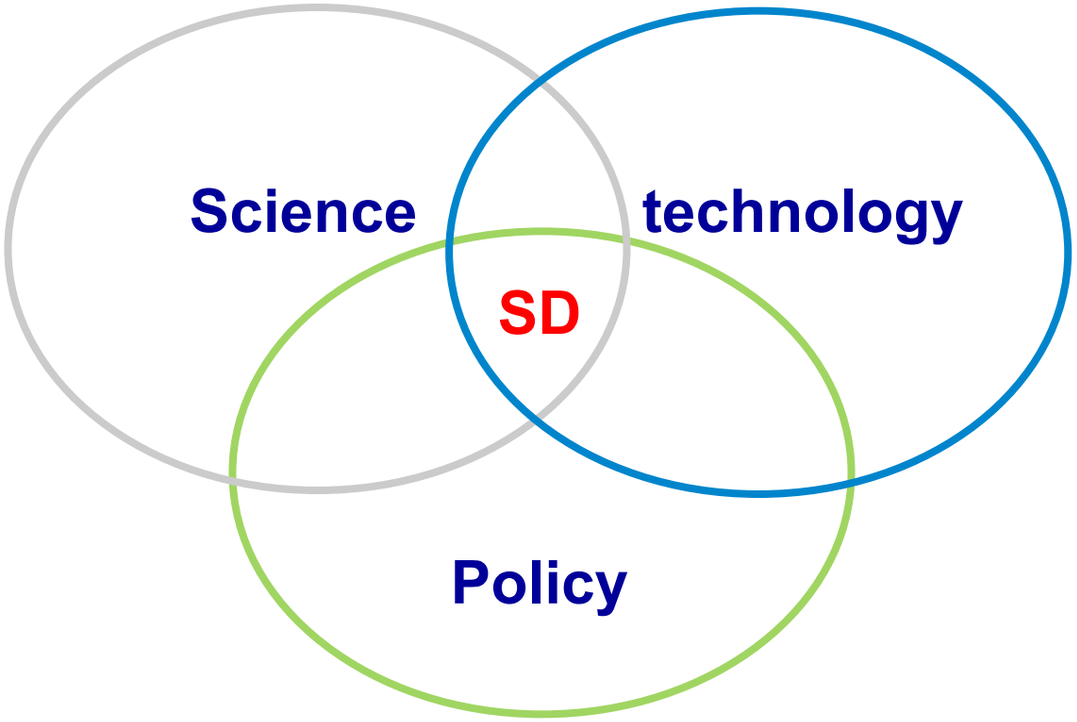
INTRODUCTION: LCS framework for Sustainability



Actions toward low carbon society for Sustainable development



SD based on innovation of science, technology and policy



CC in the Vietnam Context

CC IMPACT IN VN

VN is very sensitive to CC and disasters

- Area: 330.000km² in mainland and 1.000.000km² in Sea territory; shoreline over 3.200km long, more than 3.000 islands and many beautiful beaches.
- The North (I), the Central (II) and the South (III) of VN are different in Natural conditions and CCI.
- Population: over 90 millions, including 63 provinces and cities.
- Natural Heritages: Ha Long Bay, Phong Nha …Cultural Heritages: Hoi An City, Hue City, My Son Sanctuary…
- Vietnam is one of the most vulnerable countries to CC

CC in Vietnam context

Fast economic growth after Doi Moi

World Second Rice Exporter (emission of CH4)

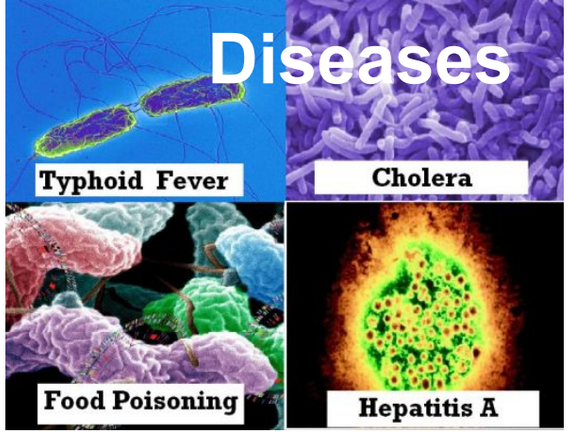
70% of population still living in rural areas

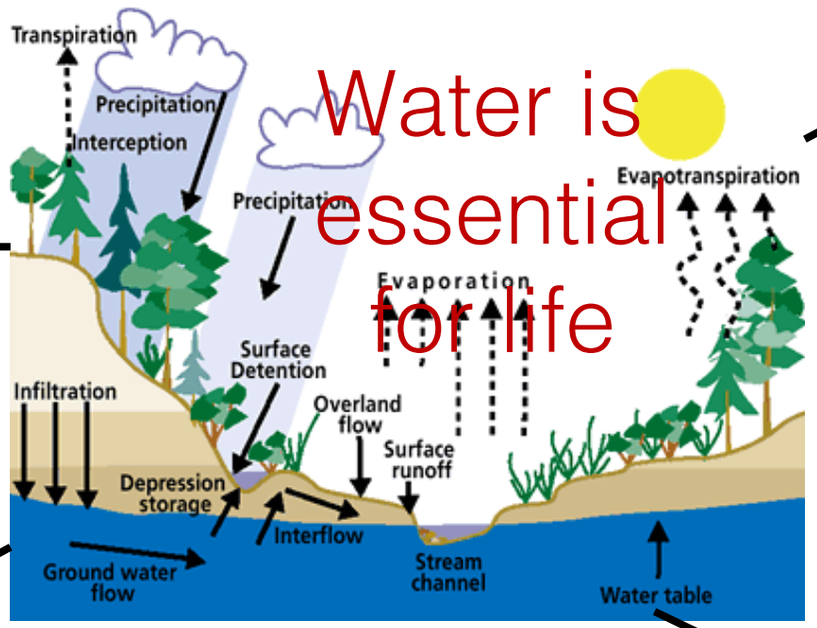
Urbanization and industrialization are absorbing a lot of agriculture land, water

Vietnam is considered as one among the most potentially affected by SLR

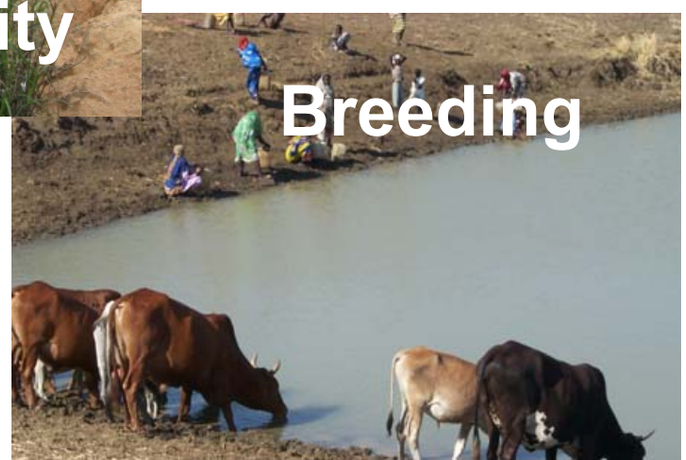
Extreme Weathers start to increase the irregularity of flood and drought in Vietnam

Vietnam is still in the list of the countries of less GHG emission, 50% of which from agriculture





Water is essential for life



Mangrove ecosystem introduction

Mangroves are woody plants which grow at the sea-land boundary of (sub)tropical regions

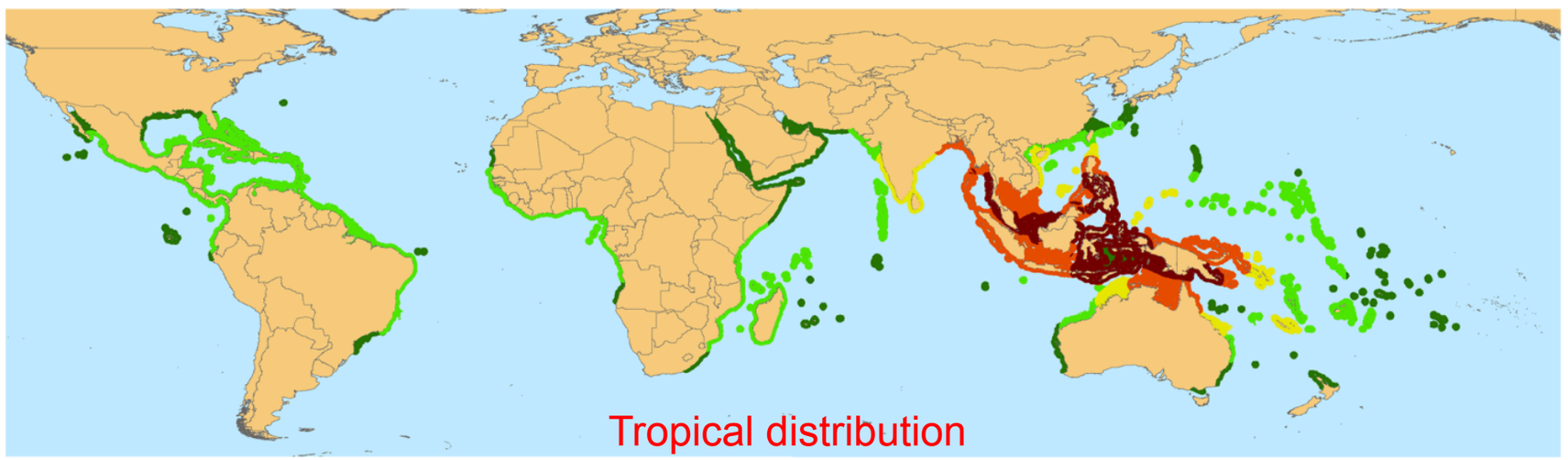
Adaptation with harsh environments

- High salinity
- Anaerobic condition

knee roots
(*Bruguiera gymnorhiza*)

pneumatophore roots
(*Avicennia alba*)

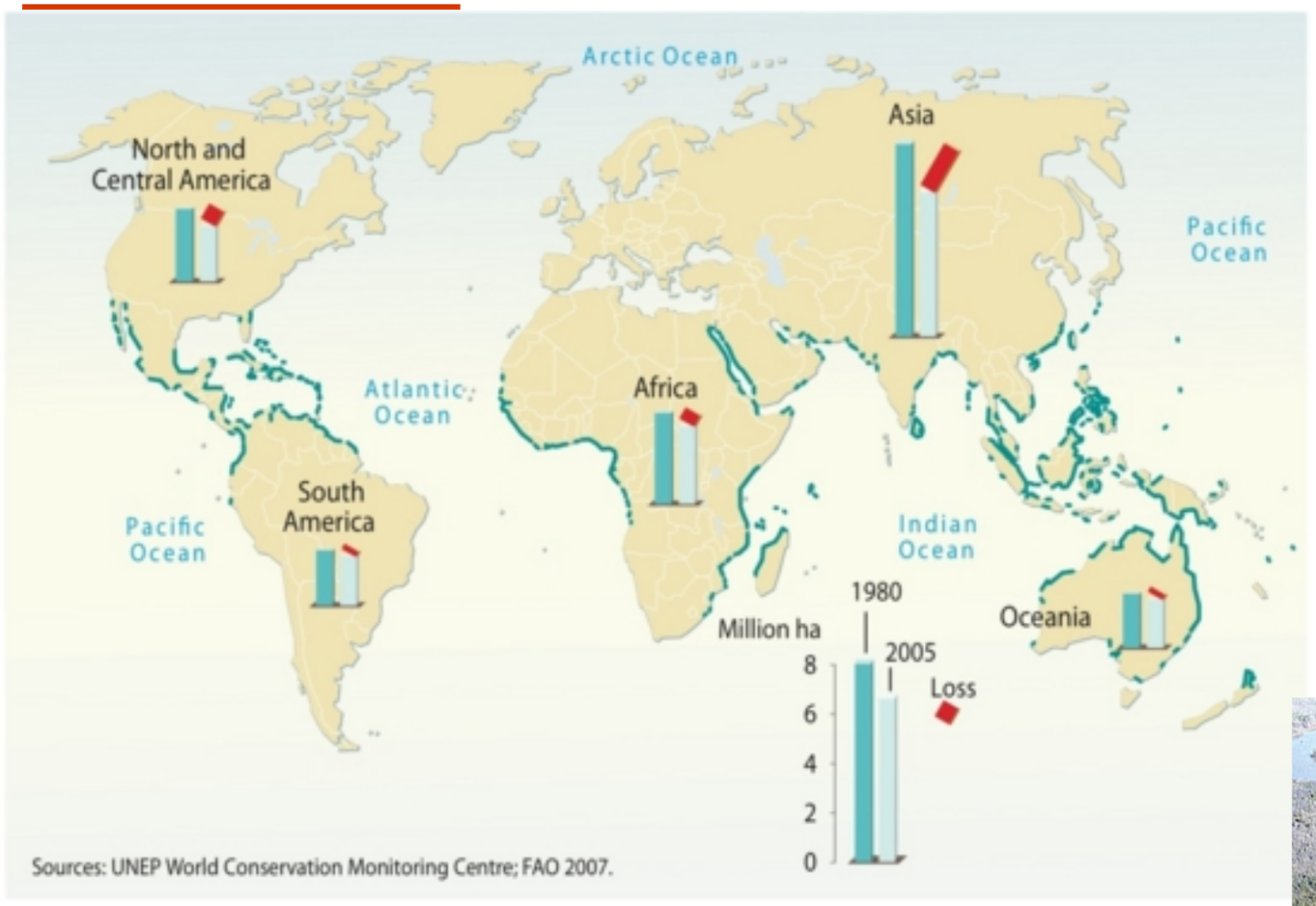
prop roots
(*Rhizophora spp.*)



Native distributions of mangrove species[1]

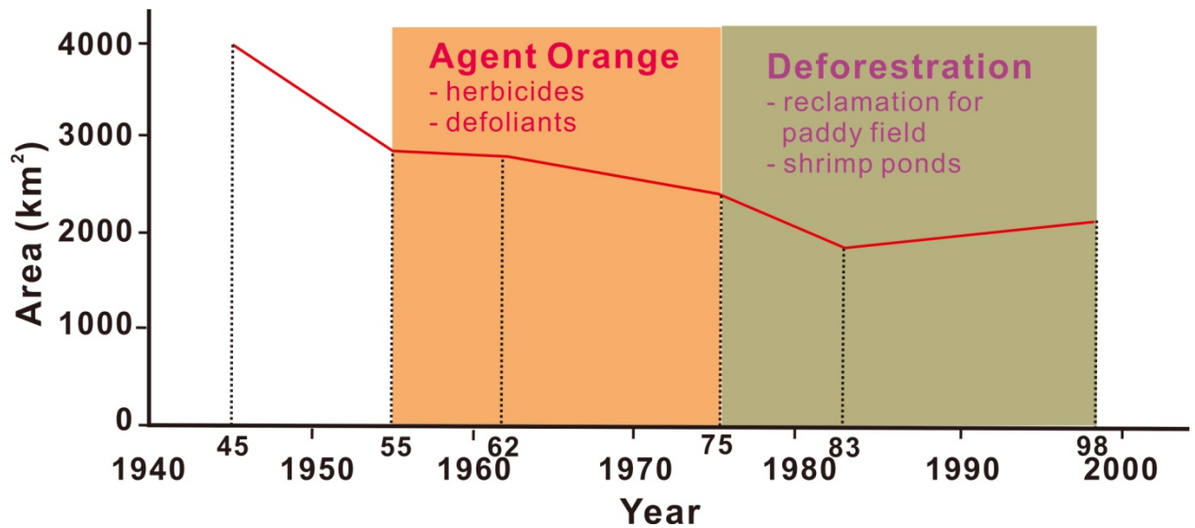
The World is Losing its Mangroves

Global loss



Vietnam loss

50% during 50 years



Facts & Causes

- From 1980–2000: Lost at least 35% of their total area in Africa, Asia, and the Americas
- Global mangrove deforestation rate is estimated to be between 1 and 2% per year
- Vietnam: Lost 50% of mangrove area

2. How can mangrove forest enhance resilience and food security of coastal community

- important renewable resources for fuels, construction, tannin, paper, dyes, and medicines
- form refuges for invertebrates and fish
- maintain high productivities of the invertebrates and fish

- support livelihood and animal protein sources for the coastal populations
- protect village, city, agriculture, and aquaculture from tropical typhoons, floods, and tsunami
- sequester carbon and offsetting greenhouse ga emissions
- filters of pollutants from land to sea

2.1.Mangrove forests are important renewable resources for fuels and support income for local community

Vietnam

mangrove timbers

Kiln at 900-1000 ^{o}C

Charcoal

export

benefits income of local populations

2.2.Mangrove forests provide many values for local community

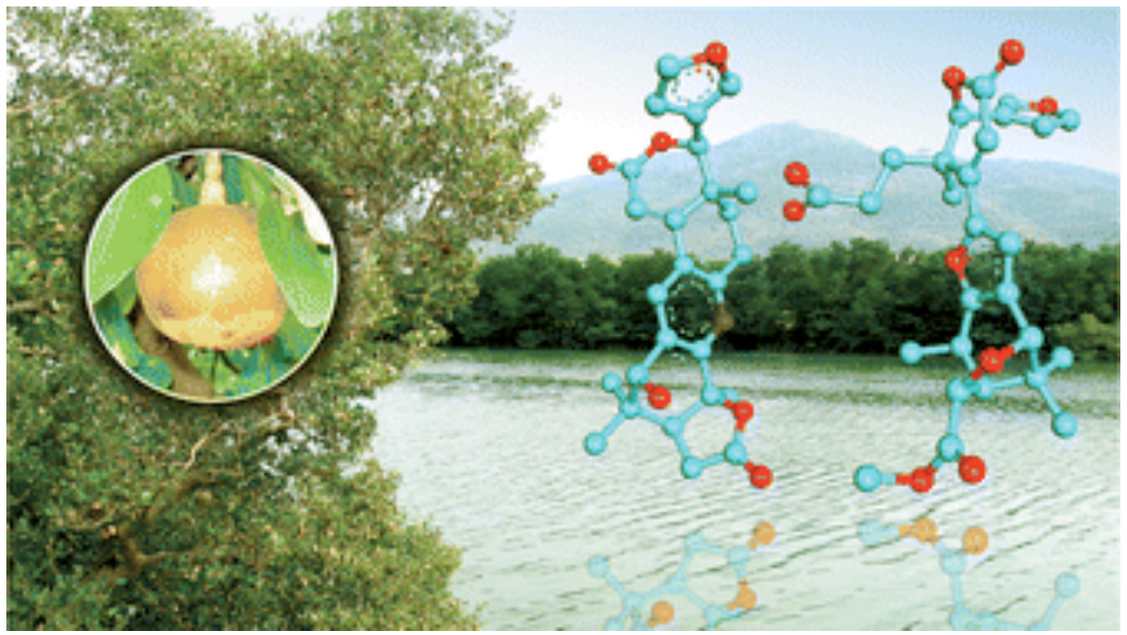
Household items: Furniture, Wax

Textiles, leather: Tannins for leather preservation

Other products: Fish, shellfish and mangrove roots for aquarium trade

Medicines

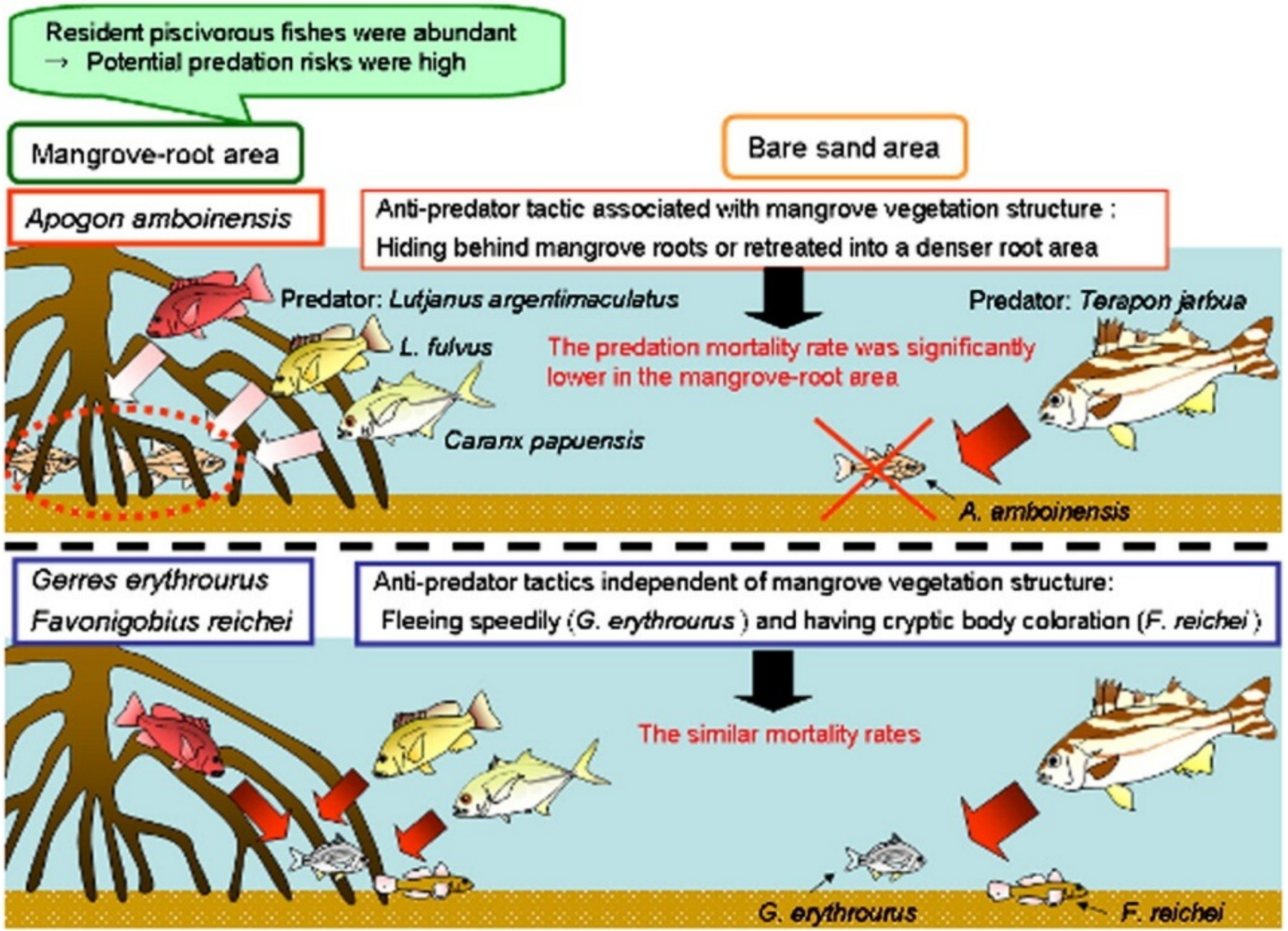
Fertilizers



2.3.Mangroves forests maintain high diversity of invertebrates and fish

Reducing predation risk [1]

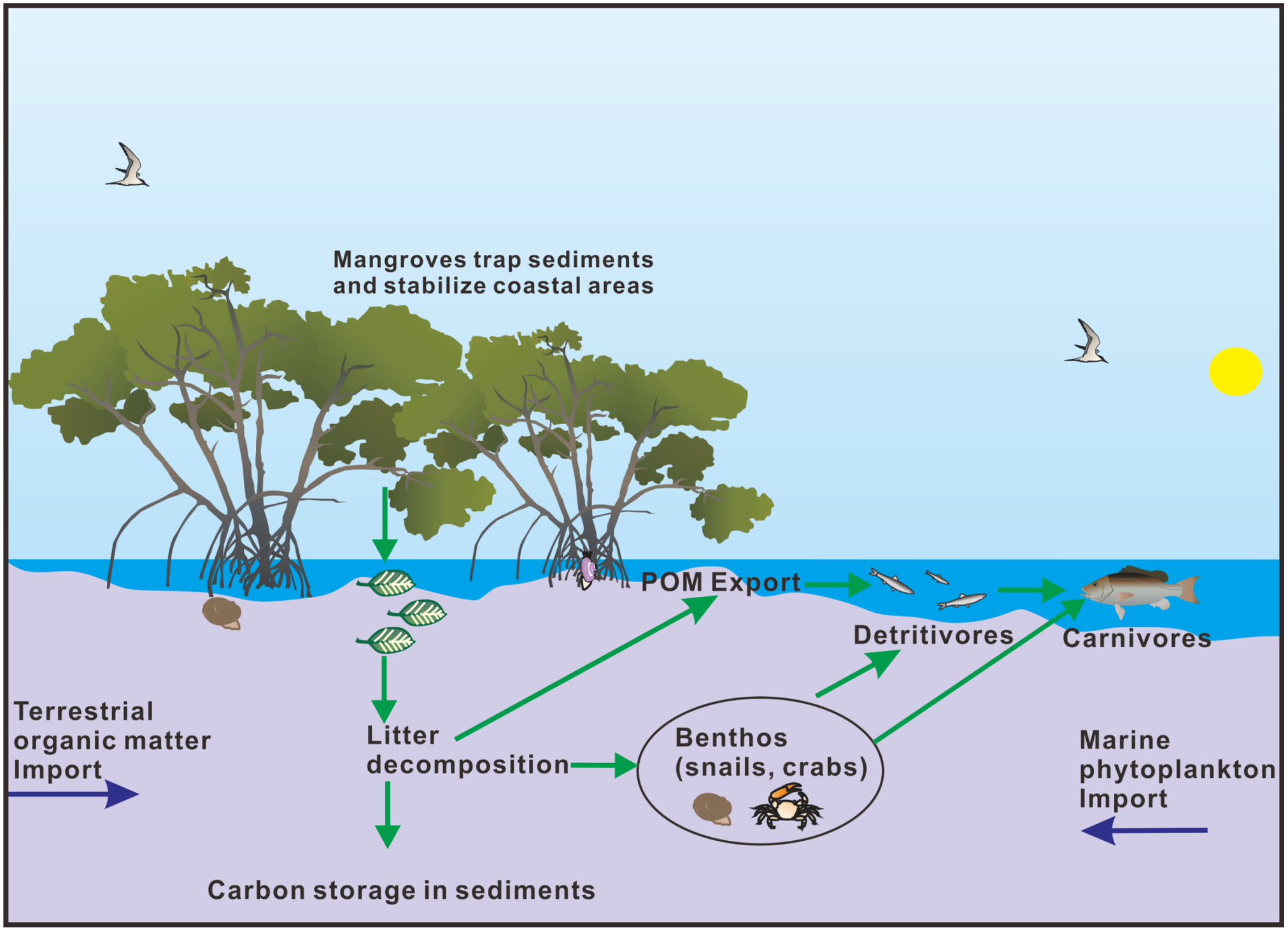
Mangroves are refuges



[1] Nanjo, K., et al. (2009). *Journal of Experimental Marine Biology and Ecology.* 405(1-2) 53-58.

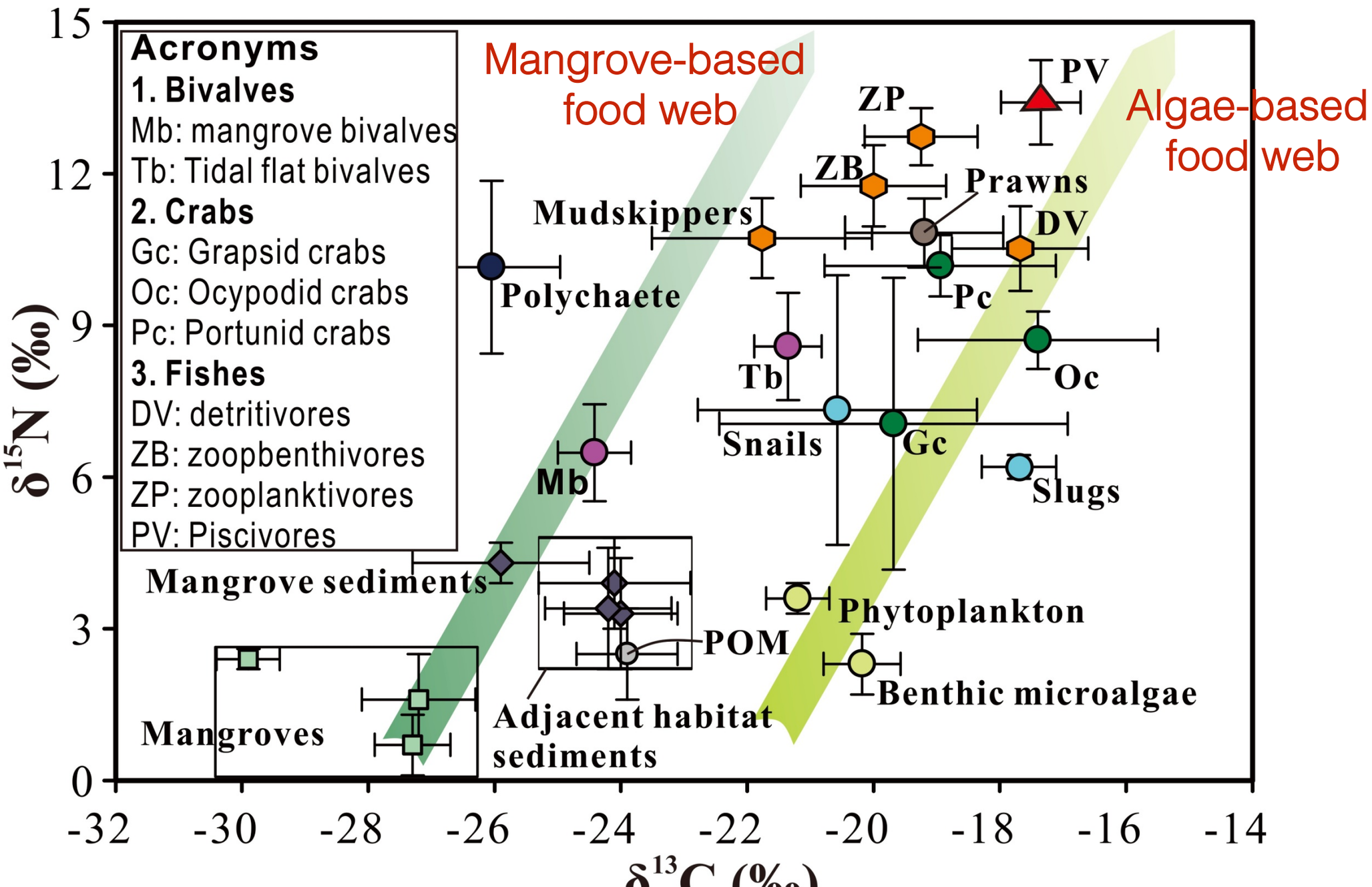
2.4. Mangroves forests maintain high diversity of invertebrates and fish

Abundance of food resources



2.4.Mangroves forests maintain high diversity of invertebrates and fish

Abundance of food resources → Evidences from stable isotope researches



2.5.Mangroves forests maintain high fisheries productivities

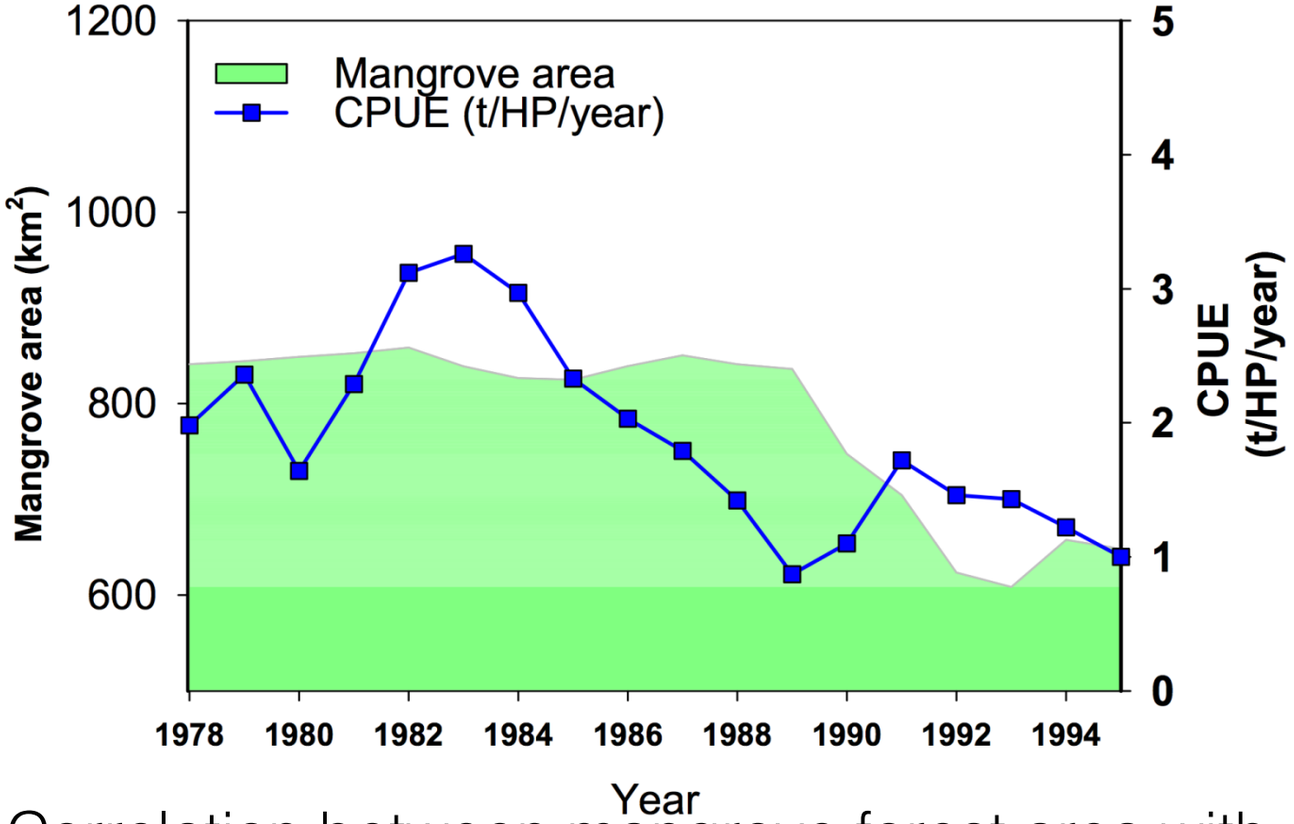
Mangrove forests

- Abundance of food resources
- Refuges for invertebrates and fish

→ high productivities of invertebrates and fish → **local community benefits**

- Fisheries productivities
- High protein food resources

1 ha mangrove forest supports 450 kg/year fish and invertebrates



Correlation between mangrove forest area with fisheries productivities in Mekong Delta, Vietnam

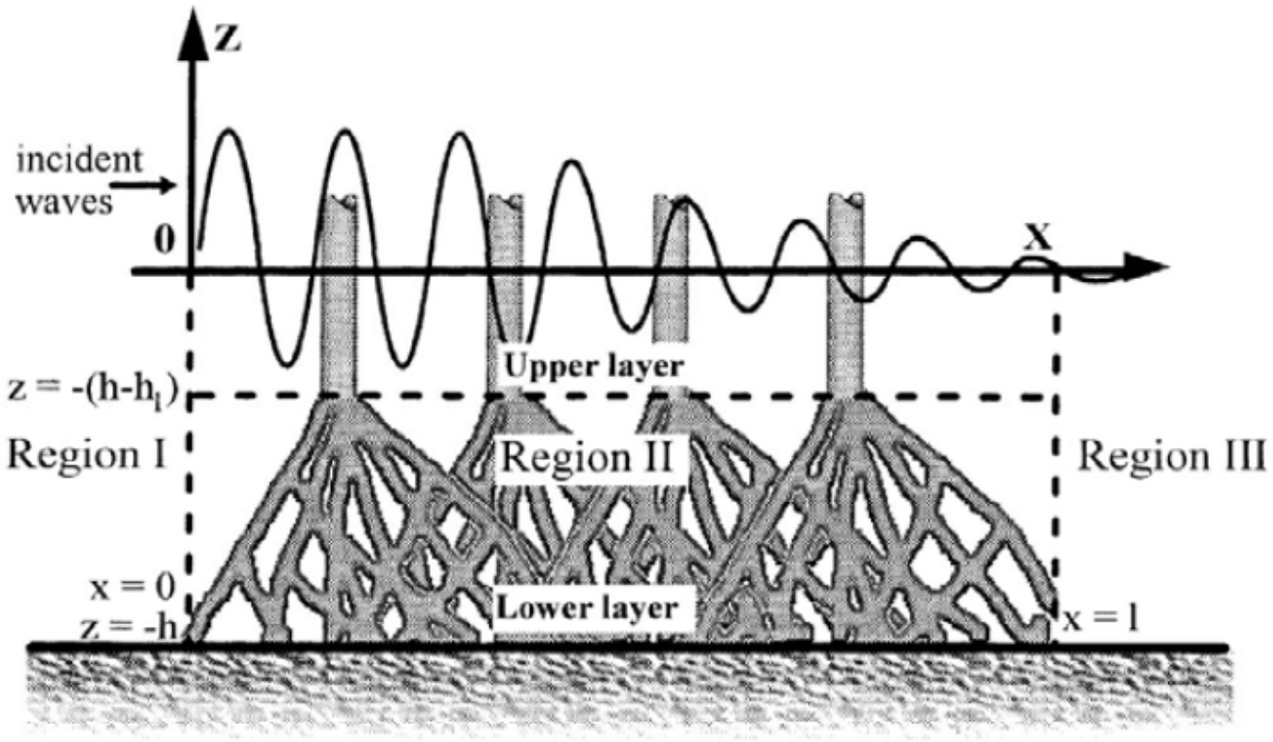
2.6. Mangroves forests are bio-guards of the coastal communities

Mangrove forests → **Attenuation** → **Protect local communities**

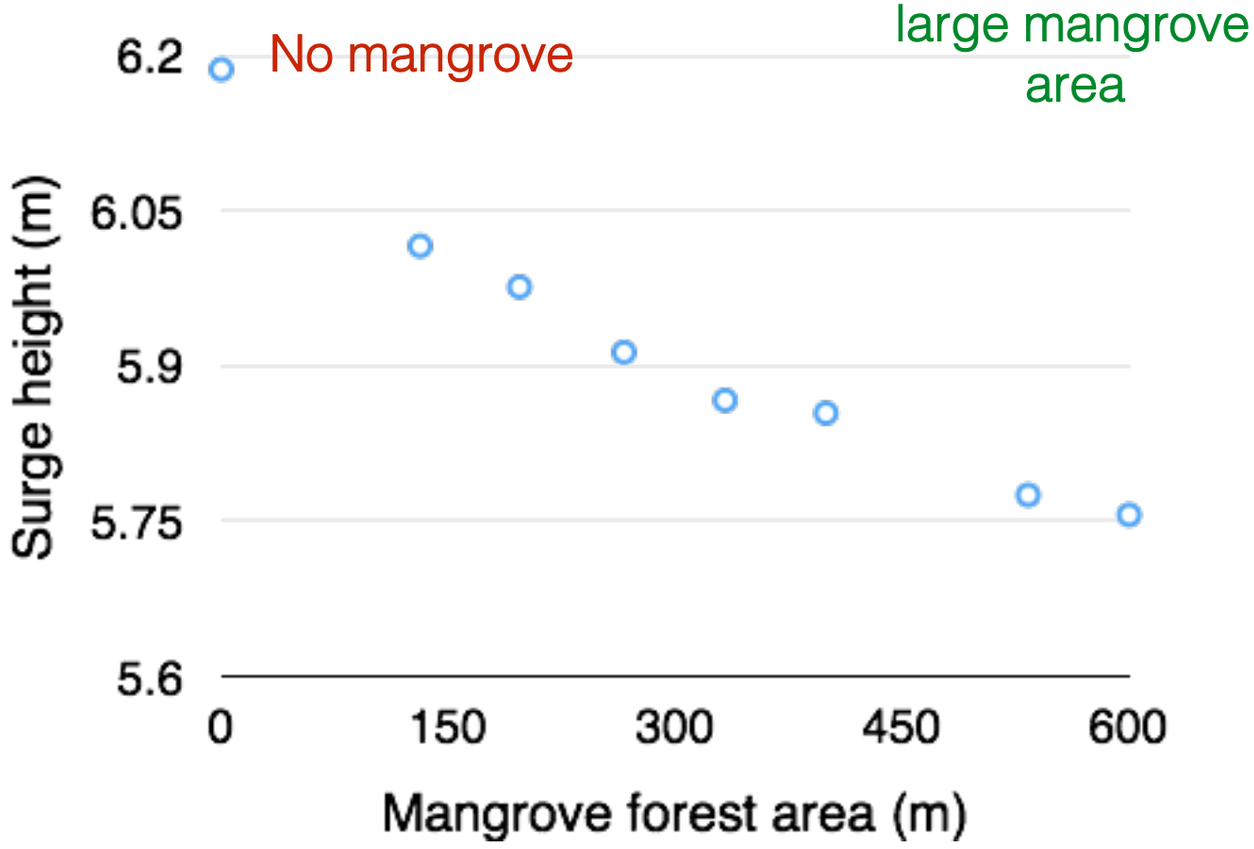
- High density of tree
- complex of root systems

→ **Attenuation**:
- sea waves
- winds

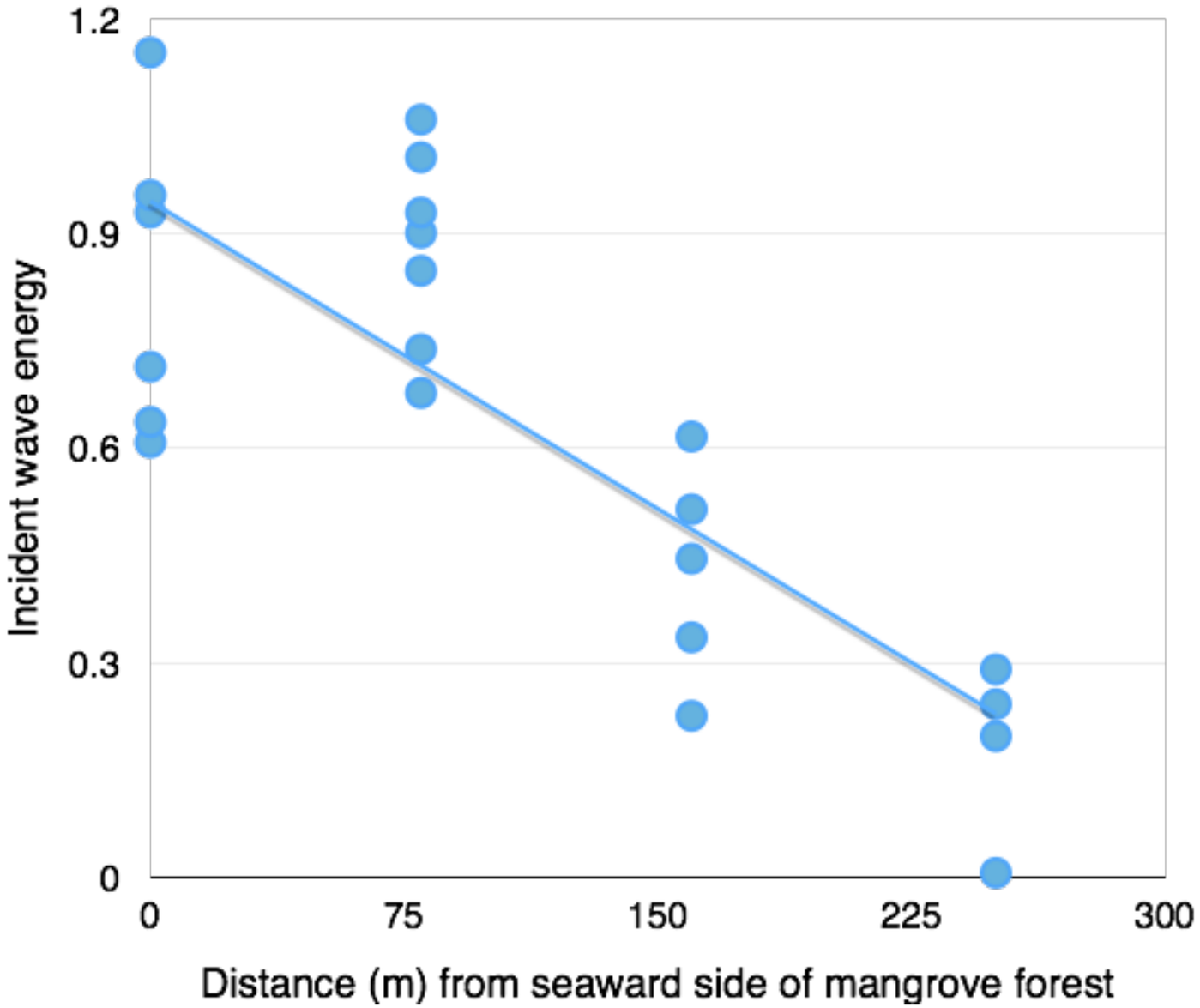
→ **Protect local communities**:
- Storm, typhoon, cyclones
- Erosion
- Surge from major storm events



(FAO, 2007)



2.7.Mangroves offset erosion in coastlines



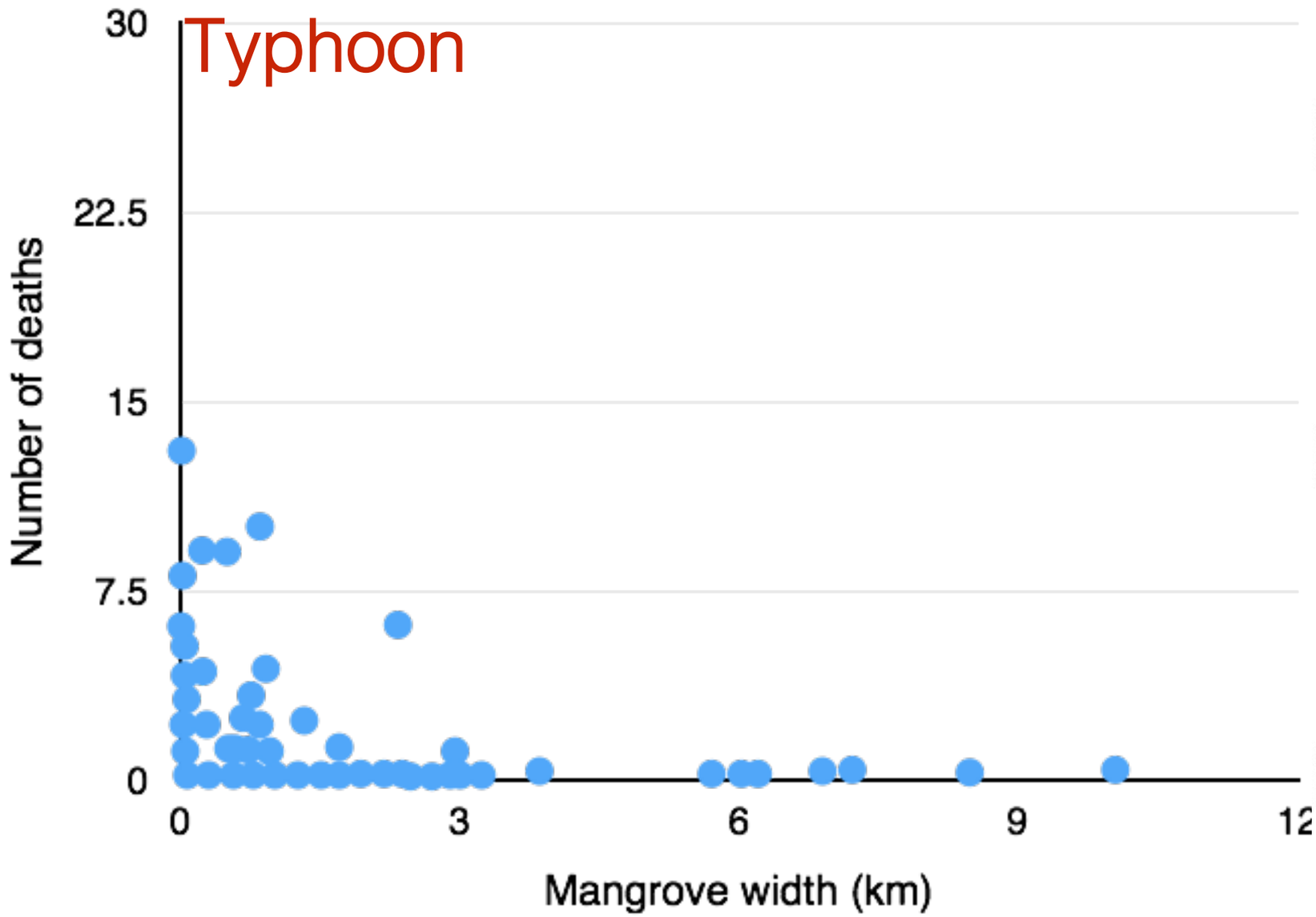
(FAO, 2007)

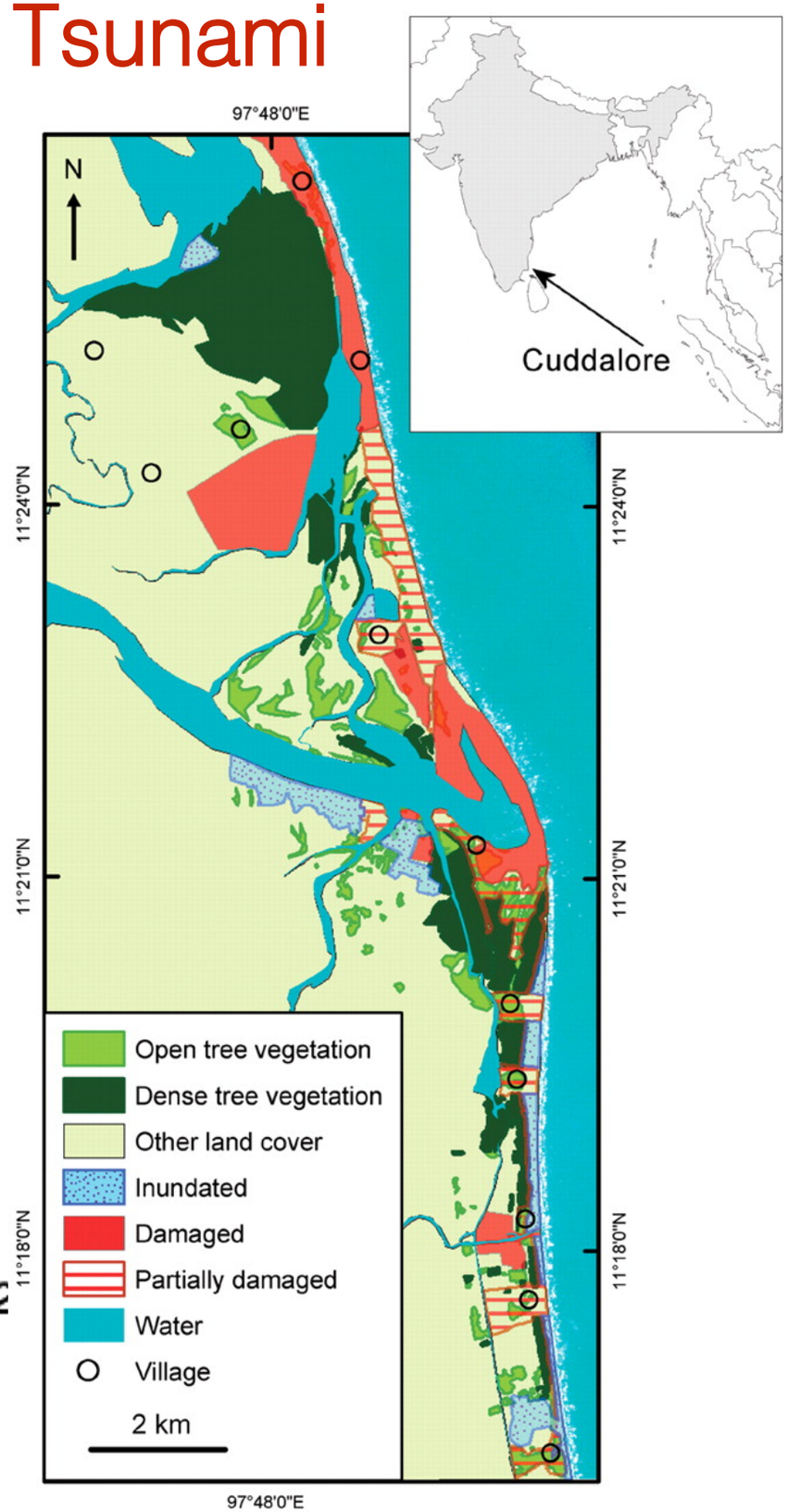
Photos: courtesy by Hong, P. N (2007)

2.8. Mangroves protect human from typhoon & tsunami

Larger mangrove area, smaller number of deaths [1]

smaller damage [2]





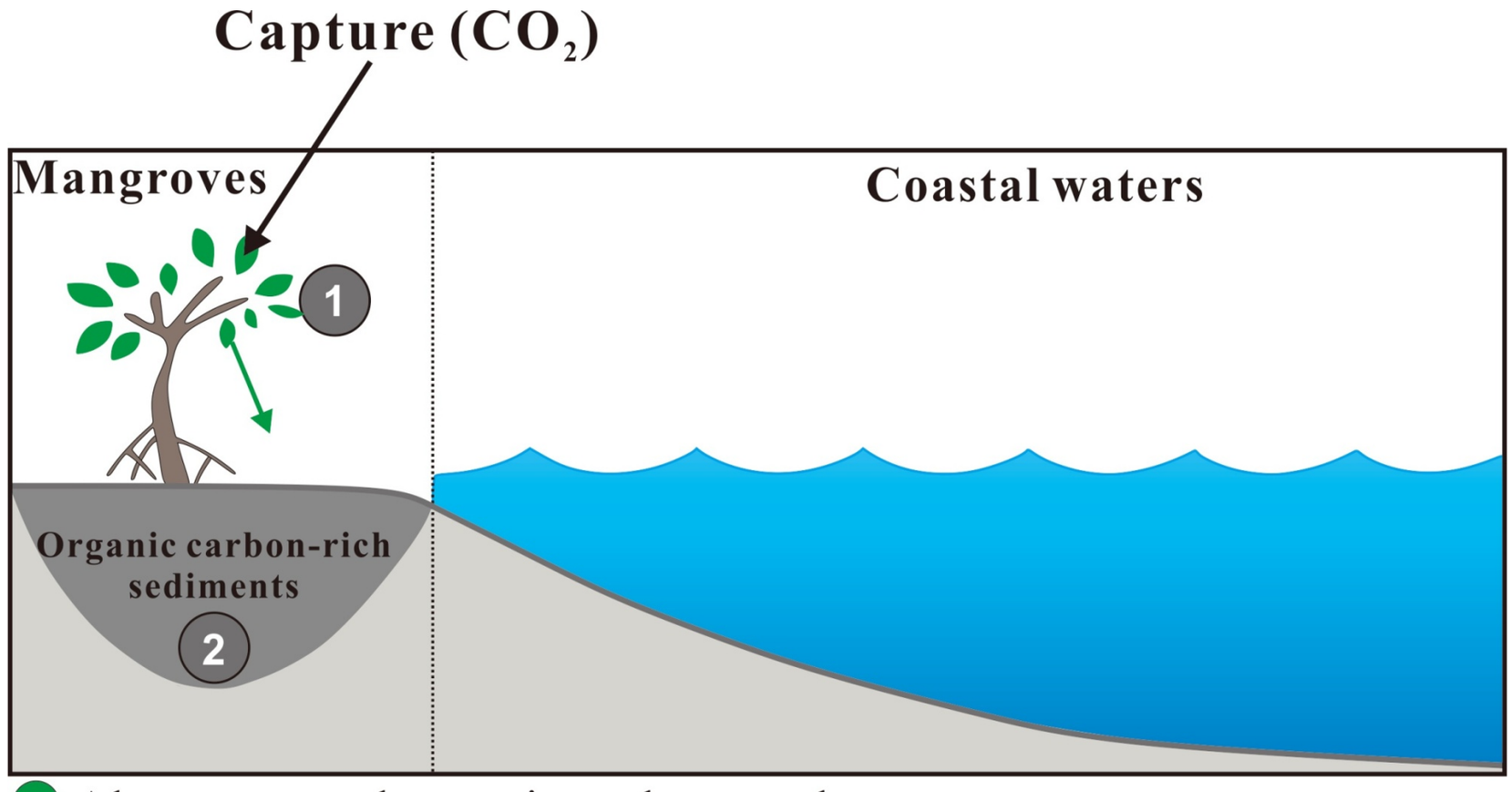
[1] Das, S. and J. R. Vincent (2009). *Proceedings of the National Academy of Sciences* 106:7357-7360.
[2] Danielsen, F., M. et al (2005). *Science* 310:643

Mangrove forests are coastal blue carbon sinks

Coastal blue carbon is the carbon captured by living coastal and marine organisms and stored in coastal ecosystems

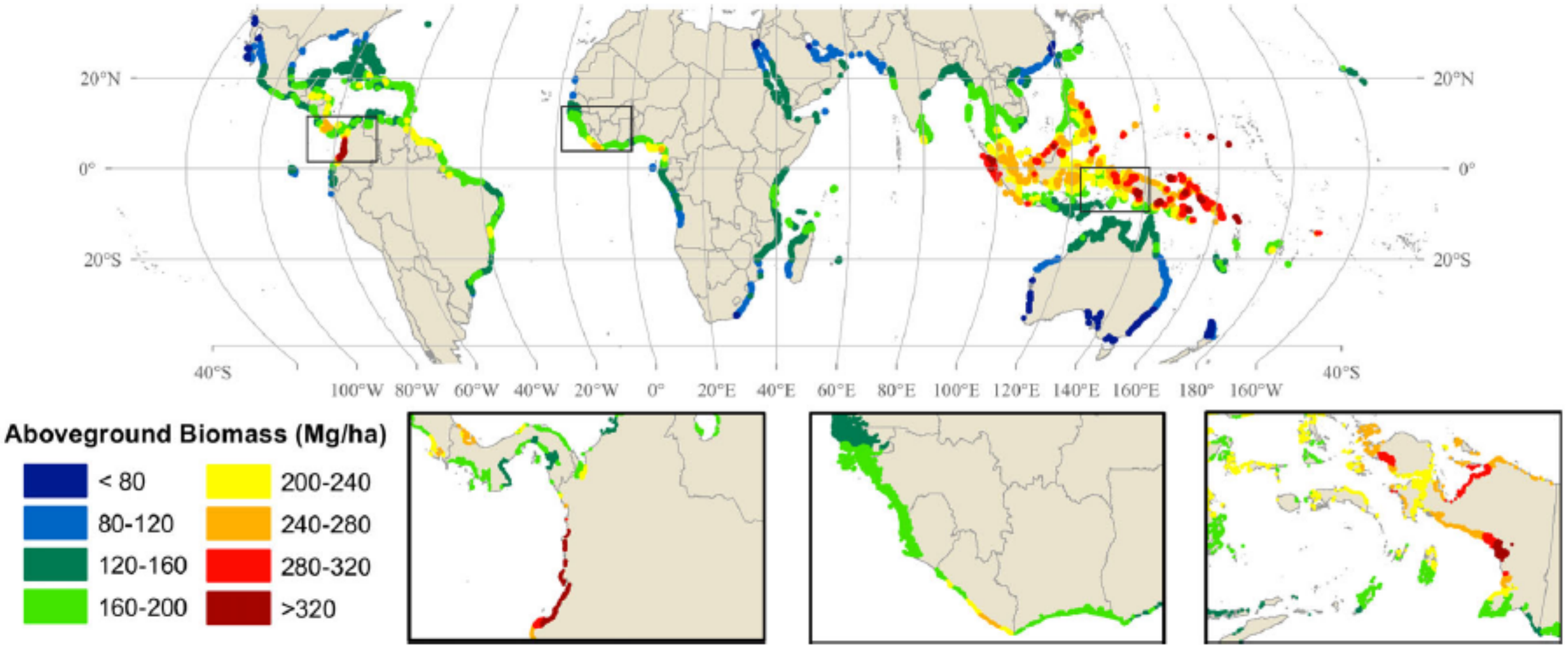
- **Carbon sequestration:** the process of capturing carbon dioxide from the atmosphere, measured as a rate of carbon uptake per year

- **Carbon storage:** the long-term confinement of carbon in plant materials or sediment, measured as a total weight of carbon stored



2.9.Mangrove forests are coastal blue carbon sinks

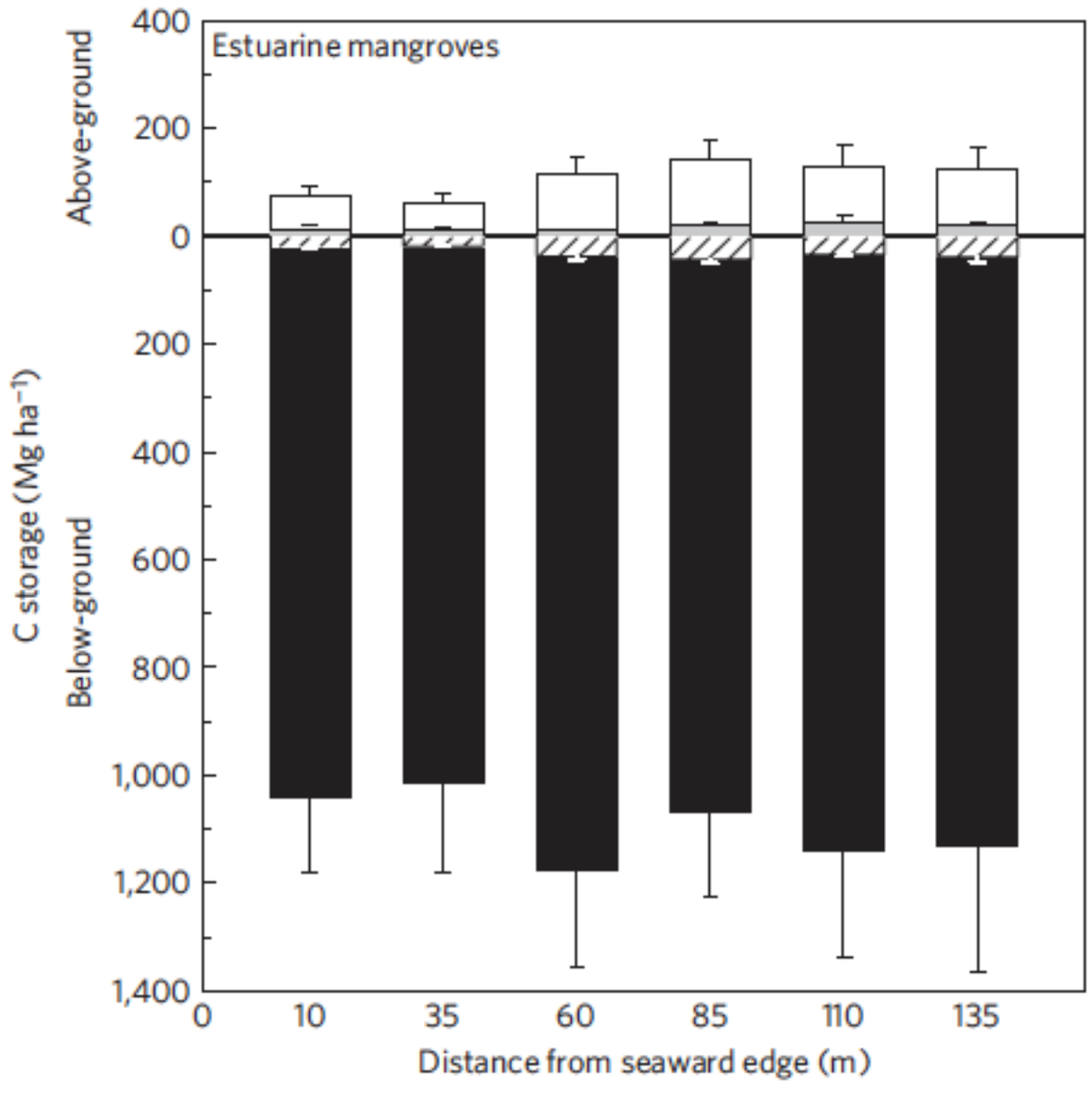
Above-ground biomass

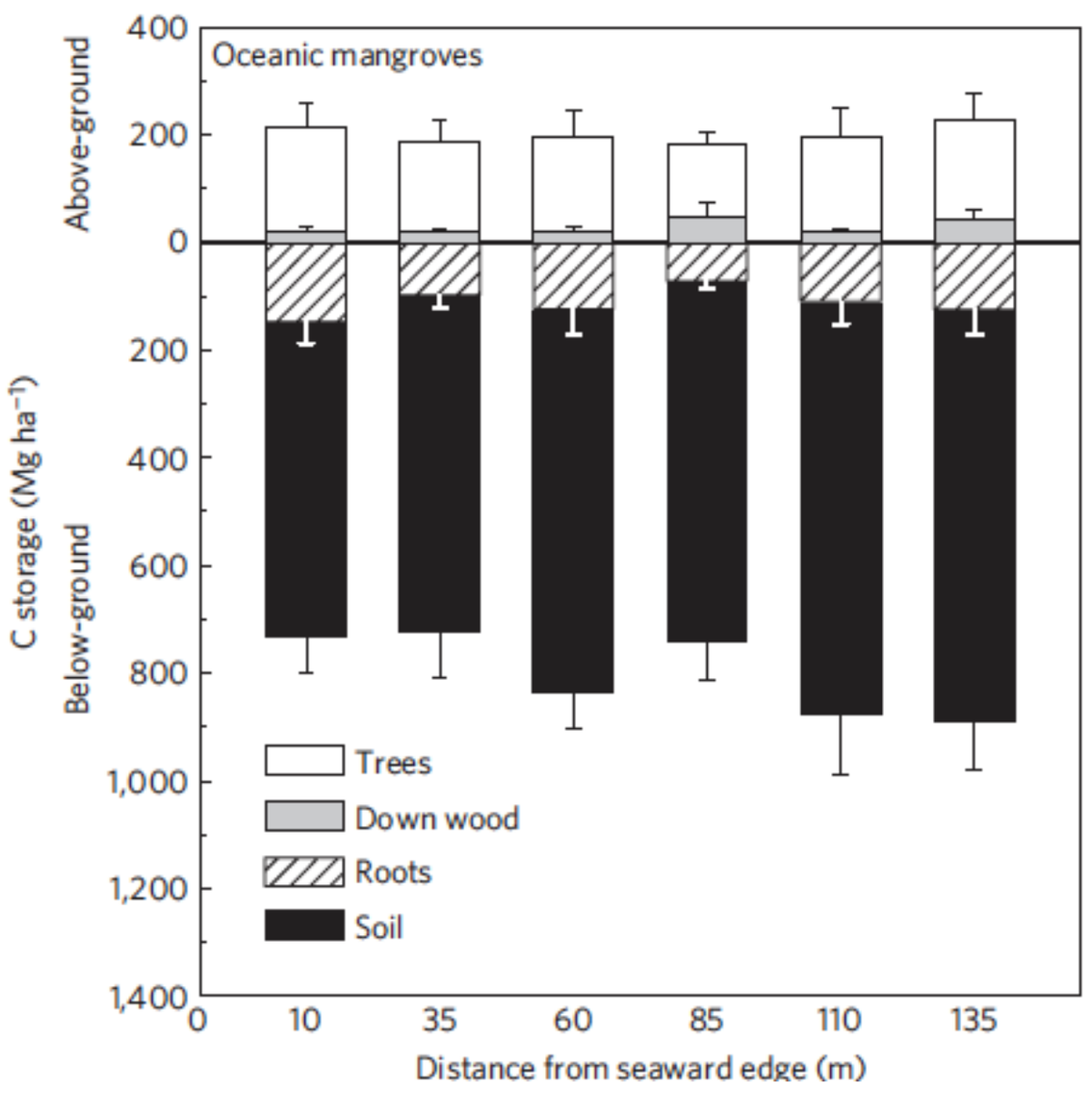


Hutchison et al. (2013). Predicting global patterns in mangrove forest biomass. Conservation Letters

2.9.Mangrove forests are coastal blue carbon sinks

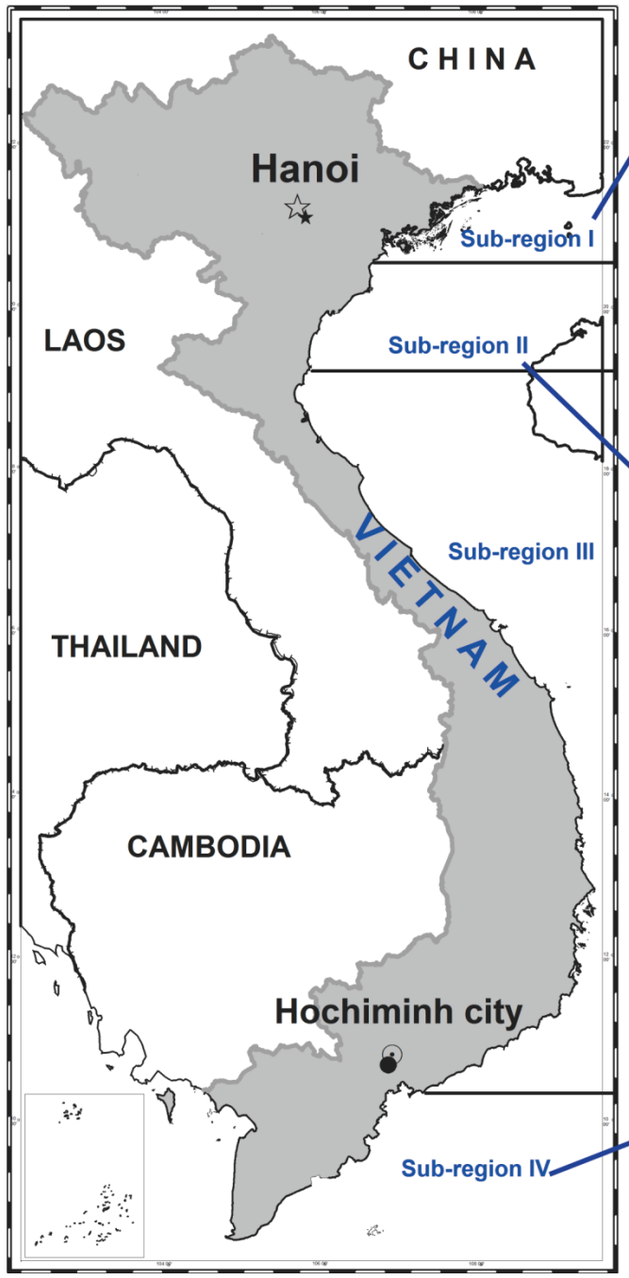
Below-ground carbon pool





Donato et al. (2011). Mangroves among the most carbon-rich forests in the tropics. Nature Geosci. 4(5): 293-297

2.9.Mangrove carbon pool measurement in Vietnam

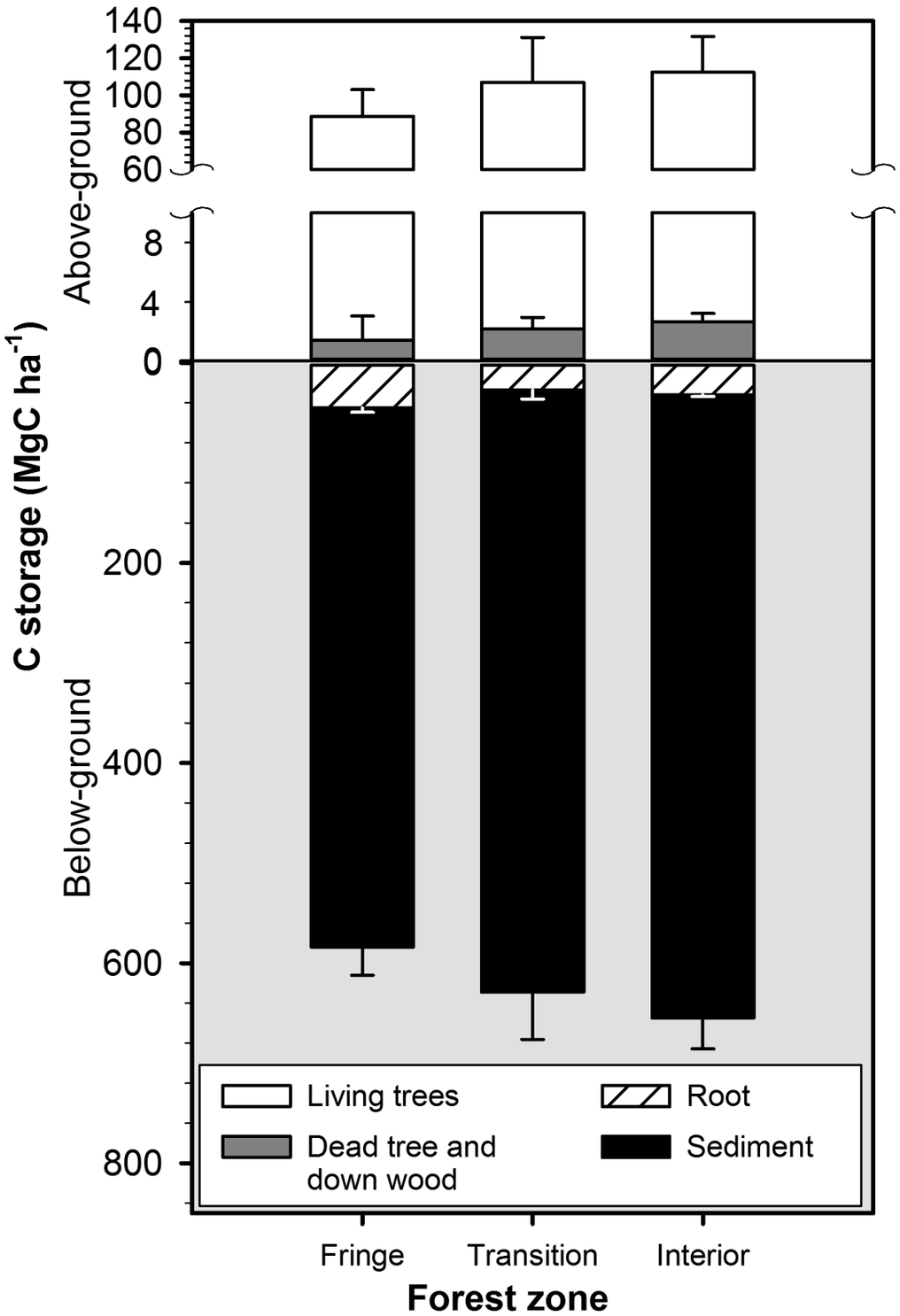


Above-ground C pool

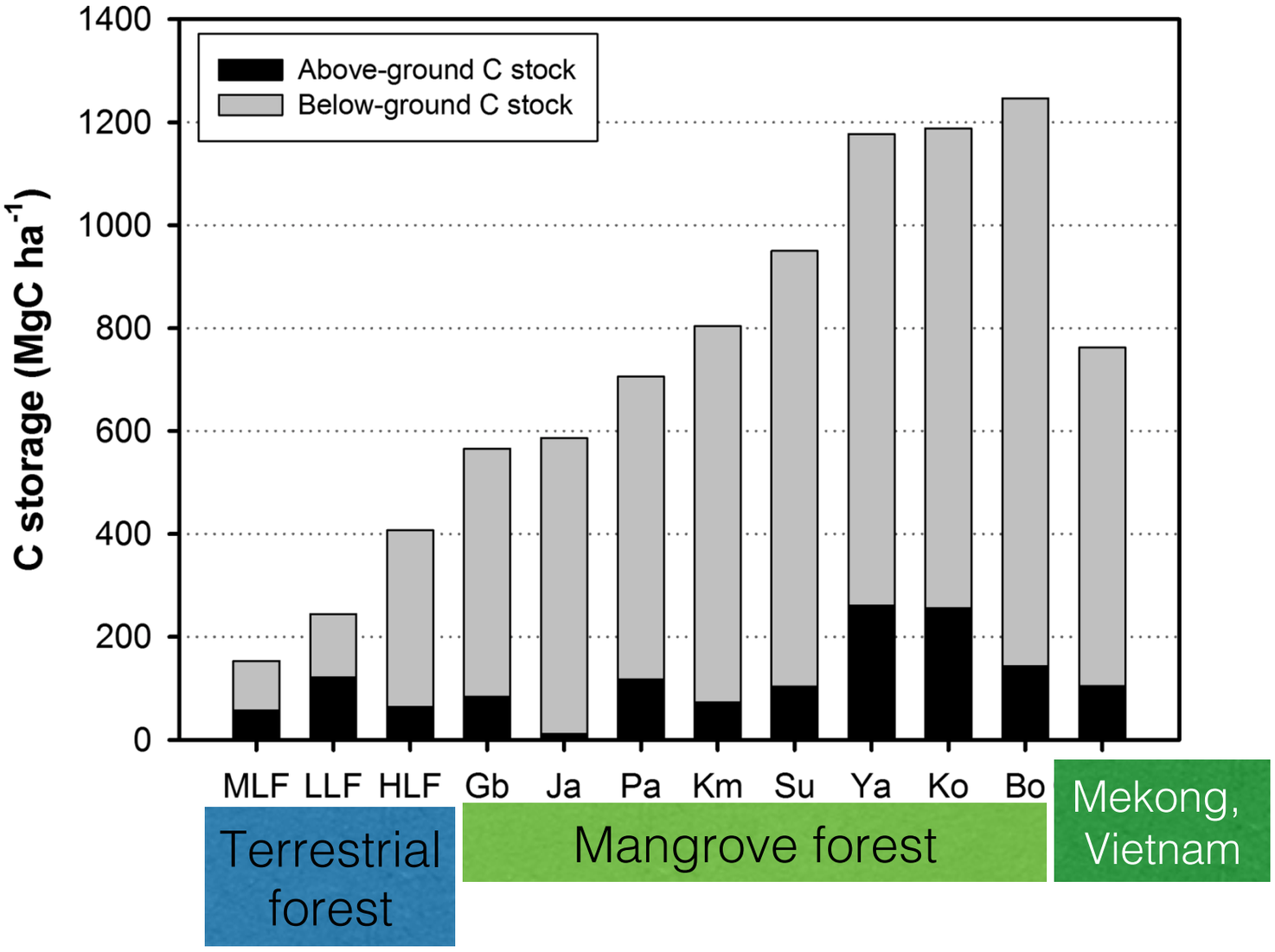
Below-ground C pool

2.9.Mangrove carbon pool measurement in Vietnam

Carbon pools

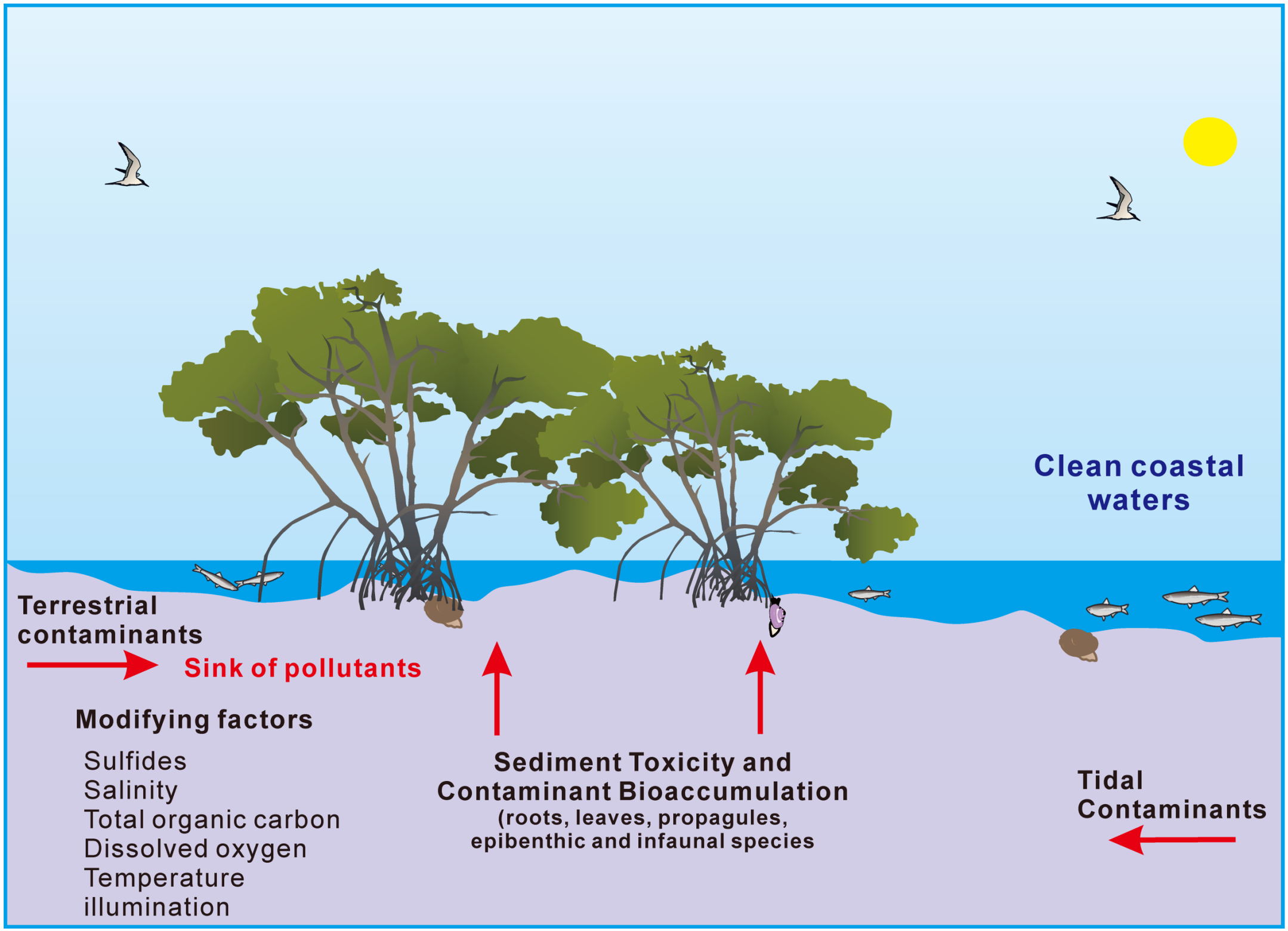


Comparison with other studies



Ganges-Brahmaputra Delta, Bangladesh (Gb); Java, Indonesia (Ja); Palau, Micronesian Island (Pa); Sulawesi, Indonesia (Su); Yap, Micronesian Island (Ya); Kosrae, Micronesia (Ko); Borneo, Indonesia (Bo) (Donato et al., 2011) ; Mexican Caribbean (Km) from (Adame et al., 2013); and high latitude forest (HLF), middle latitude forest (MLF), and low latitude forest (LLF) (Dixon et al., 1994).

2.10.Mangrove forests are filters of pollutants from land to sea



Lewis et al. (2011)

3. Enhancing Resilience of mangrove ecosystem

Conserving/ protecting

Maintaining

Ecosystem functions

Sustainable use

Future research collaborations in implementing 3E+1 NEXUS in mangrove ecosystem of Red River Delta, Vietnam, China, Indonesia, Thailand, Srilanka…

1. Mangrove Ecosystem Energy

- To quantify above- and below-ground carbon pools in mangrove forest
- To develop a reducing carbon emission from deforestation and degradation (REDD+) scheme and carbon market for mangrove forest

2. Mangrove Ecosystem and coastal Environment

- To examine functional roles of mangroves in supporting diversity of invertebrates and fish in coastal waters
- To examine connectivity between mangrove forest and coastal ecosystems (coral reef, seagrass, tidal flat)
- To analyze the capacity of mangrove ecosystem in absorbing pollutant for reducing marine pollution
- To examine the functional roles of mangrove forest in mitigating disasters: typhoon, erosion, flood

Future research collaborations in implementing 3E+1 NEXUS in mangrove ecosystem of Red River Delta, Vietnam, China, Indonesia, Thailand, Srilanka…

3. Mangrove Ecosystem and Food security

- To figure out how mangrove ecosystem contribute to enhance the food security of the coastal community

4. Economic evaluation of mangrove ecosystem

To evaluate ecosystem services of mangrove ecosystem for enhancing food security and sustainable development of coastal community

To develop a climate smart livelihood model based on sustainable use and conserving mangrove ecosystem

5. Resilient assessment of socio-ecological system in Vietnam coastal zone

To develop strategy for enhancing resilience and low carbon society to offset climate change based on sustainable use of ecosystem services of mangrove forests.

Conclusions

1. Vietnam mangrove ecosystem (in Red river and Mekong deltas…) is very suitable for implementing 3E+1 NEXUS project for:

- Conserving biodiversity of marine ecosystem
- Responding to climate change and ecosystem degradation
- Reducing carbon emissions from forest deforestation and degradation (REDD+)
- Building up low carbon society and climate smart village and community.
- Enhancing resilience of socio-ecological system in Vietnam

Conclusions

2. Implementing 3E+1 NEXUS project is good contribution to:

- Sustainable development;
- Sustainability science;
- Building up low carbon society and nature harmonious society;
- Enhancing resilience of human and nature system;
- Smart response to climate change and environmental protection;
- Improving Climate smart innovation(science, technologies, policy) and livelihood;
- Development of sustainability science, 3E NEXUS Human resources
- …

Conclusions

3. The 3E NEXUS project would be Implemented through:

- Sustainable collaboration among the members of Asia Pacific and others;
- Social Innovation network;
- Combination of indigenous and modern knowledge;
- Climate smart innovation (science+technologies+ institutional and policy) and livelihood;
- Plus 1- economy: 3E balanced economy;
- 3E+1 NEXUS capacity building
- …

Acknowledgements

IR3S Integrated Research System for Sustainability Science サステイナビリティ学 連携研究機構

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