IPCC WG 2 Third Assessment Report

～ Impacts、Adaptation、Vulnerability～

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1. Major Findings of IPCC WG2 TAR
2. Impacts on Major Sectors
3. Impacts on Asian Regions

Major Findings of IPCC Third Assessment Report (TAR)

- **The Earth's climate system has changed, globally and regionally, with some these changes being attributable to human activities.**

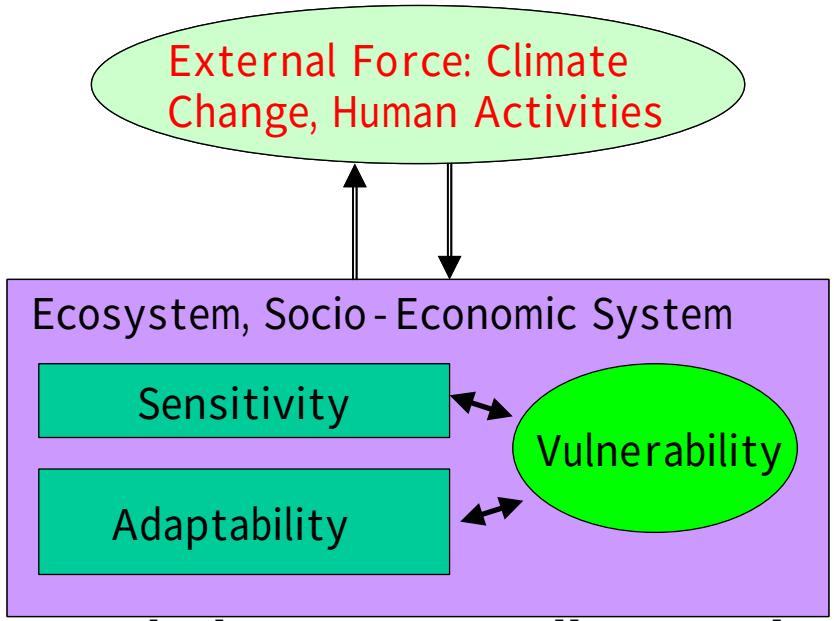
- **CO_2, surface temperatures, precipitation and sea level are projected to increase globally during the 21st Century because of human activities.**

- **Biological systems have already been affected in many parts of the world by climate changes, particularly increases in regional temperature.**

- **Projected climate changes will have both beneficial and adverse effects on water resources, agriculture, natural ecosystems and human health, but the larger the climate changes the more the adverse effects dominate.**

- **There are many technological options to reduce near-term GHG emissions and opportunities for lowering costs, but barriers to the development of climate friendly technologies need to be overcome.**

Fig. 1 Impacts, Adaptation, Vulnerability



Sensitivity : the degree to which a system will respond to a change in climate conditions.

Adaptability : the degree to which adjustments are possible in practices, processes, or structures of systems to projected or actual changes of climate. Adaptation can be spontaneous or planned.

Vulnerability: the extent to which climate change may damage or harm a system. It depends not only on a system's sensitivity but also on its ability to adapt to new climate conditions.

Both the magnitude and the rate of climate change are important in determining the sensitivity, adaptability, and vulnerability of a system.

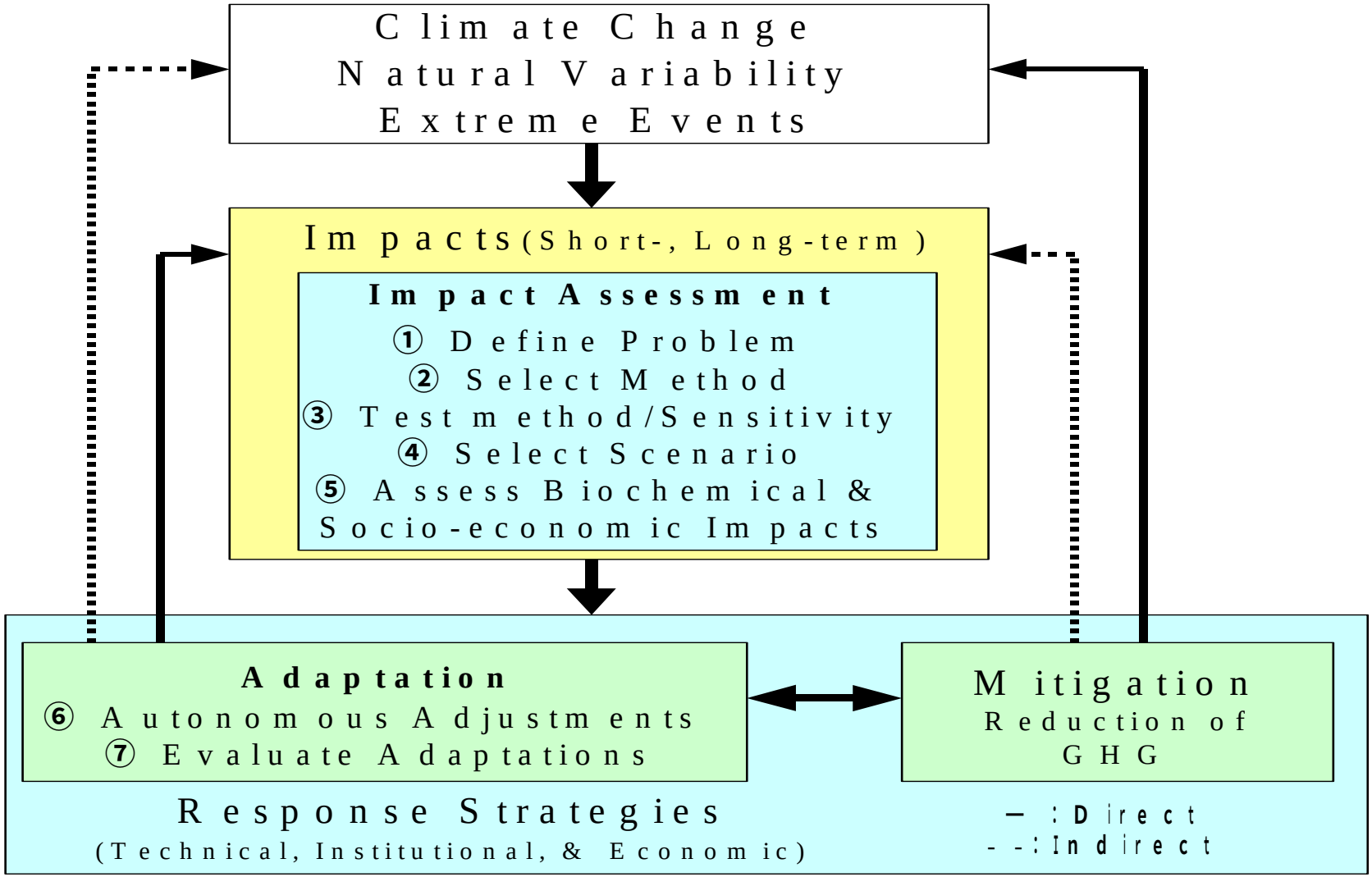


Fig.2 Framework of Impacts Assessment

What's New?

① New Framework

Scientific Assessment →+Policy Relevant Issues

② Quantification of Impacts

Introduction of Level of Confidence

③ Observed Impacts on Physical and Biological System

④ Beneficial(+)/Adverse(-) Impacts

⑤ Natural Variability and Extremes

⑥ Adaptation and Synthesis

⑦ Detailed Regional Impacts & Current Issues such as Food Security, Water Resources, and Urban Environmental Issues.

New Framework: IPCC WG II TAR Contents

Summary for Policy Makers (SPM)

Technical Summary (TS)

Part I. Setting the Stage for Impact, Adaptation, and Vulnerability Assessment

Ch.1～3 Overview, Methods and Tools, Developing and Applying Scenarios

Part II. Sectors and Systems: Impacts, Adaptation, and Vulnerability

Ch.4～9 Hydrology and Water Resources, Ecosystems and Their Goods and Services, Coastal Zones and Marine Ecosystems, Human Settlements, Energy, and Industry, Insurance and Other Financial Services, Human Health

Part III. Regional Analyses: Impacts, Adaptation, and Vulnerability

Ch.10～17 Africa, Asia , Australia and New Zealand, Europe, Latin America, North America, Polar Regions (Arctic and Antarctic), Small Island States

Part IV. Global Issues and Synthesis

Ch.18 Adaptation to Climate Change in the Context of Sustainable Development and Equity

Ch.19 Lines of Evidence for Vulnerability to Climate Change : A Synthesis

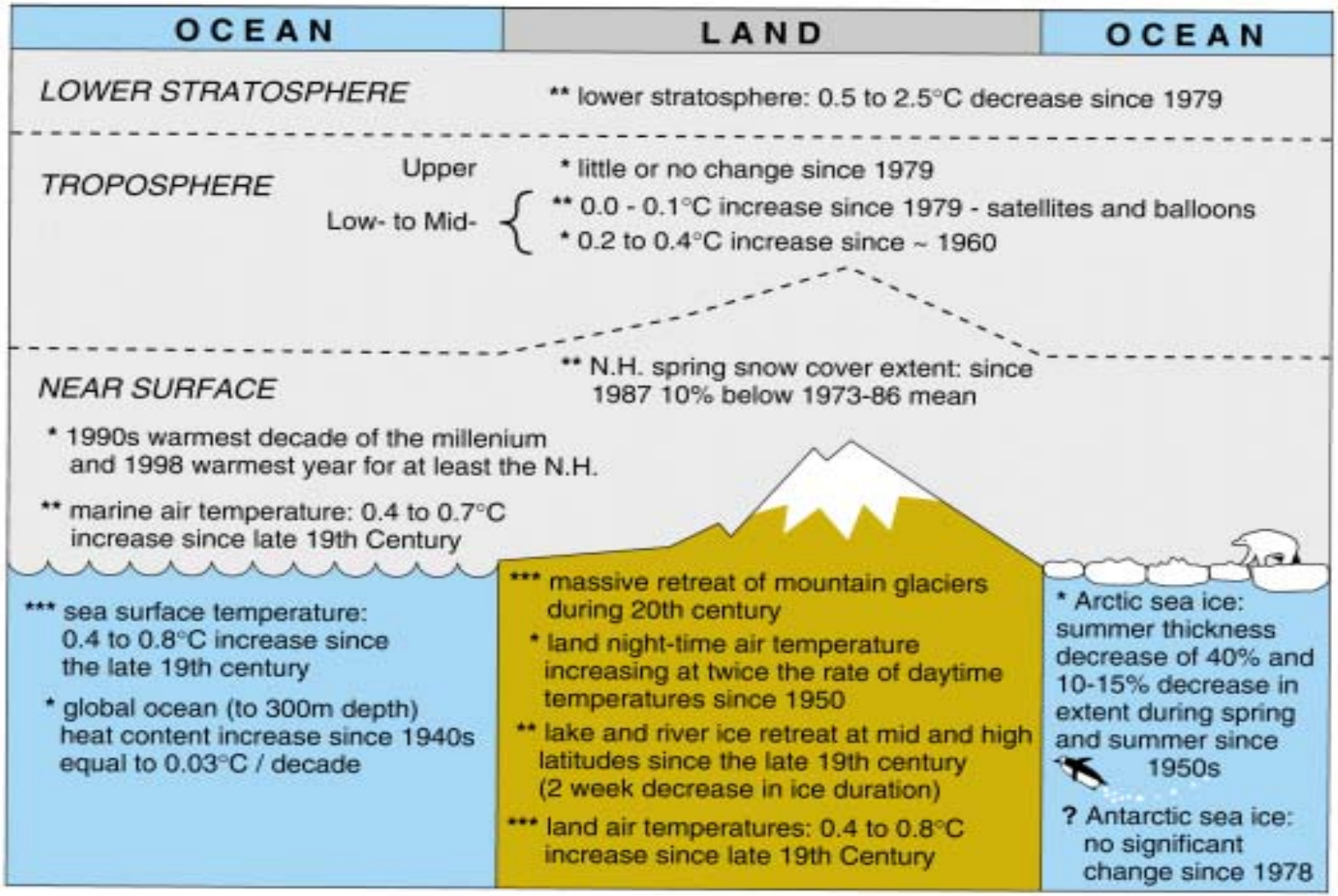
Quantification of Impacts

Level of Confidence

Working Group 1		*Working Group2*	
>99%	**Virtually Certain**		
90-99%	**Very Likely**	**>95%**	**Very High Confidence**
66-90%	**Likely**	**67-95%**	**High Confidence**
33-66%	**Medium Likelihood**	**33-67%**	**Medium Confidence**
10-33%	**Unlikely**	**5-33%**	**Low Confidence**
1-10%	**Very Unlikely**	**< 5%**	**Very Low Confidence**
< 1%	**Exceptionally Unlikely**		

Observed Impacts

Fig. 3 Temperature Indicators



Likelihood

- *** **Virtually certain (probability > 99%)**
- ** **Very likely (probability > 90% but ≤ 99%)**
- * **Likely (probability > 66% but < 90%)**
- ? **Medium likelihood (probability > 33% but ≤ 66%)**

Observed Impacts on Biological System.

- Bird migration patterns are changing and birds are laying their eggs earlier.
- Growing season in the Northern Hemisphere has lengthened by about 1-4 days / 10 years during the last 40 years.
- Earlier flowering of trees.
- There has been a pole-ward and upward migration of plants, insects and animals.
- .....

Fig.4 Observed Impacts on Physical and Biological Systems

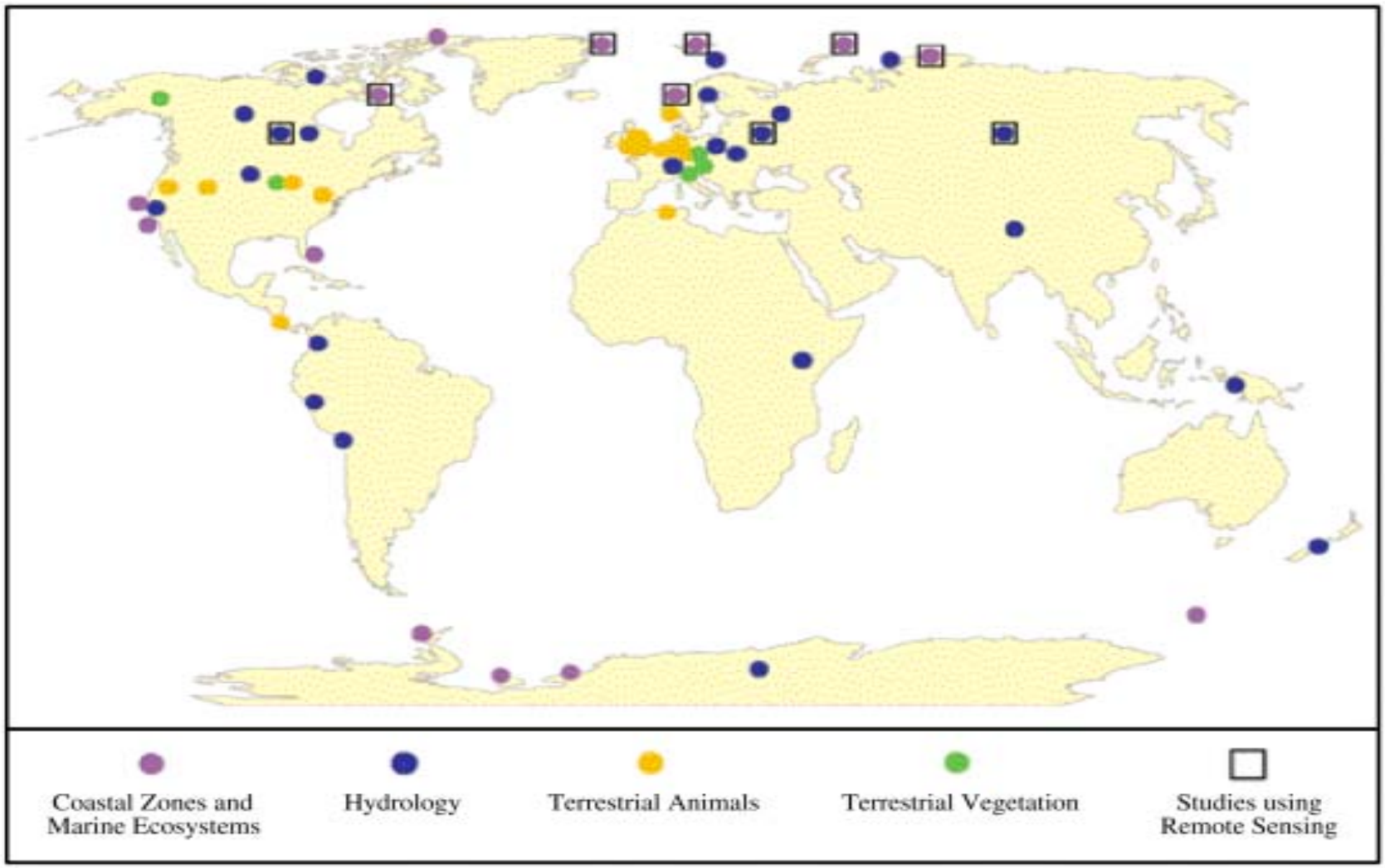


Figure TS-12: Locations at which studies have documented temperature-related regional climate change impacts on physical and biological systems in the 20th century. Hydrology, glacial retreat, and sea-ice data represent decadal to century trends. Terrestrial and marine ecosystem data represent trends of at least 2 decades. At these sites there are data for single or multiple impacts that are consistent with known mechanisms of physical/biological system responses to climate and observed regional climate changes. (For reported impacts spanning multiple continents, a representative site was selected for each continent).

Beneficial(+)/Adverse(-) Impacts

Projected climate changes will have both beneficial and adverse effects on water resources, agriculture, natural ecosystems and human health, but the larger the climate changes the more the adverse effects dominate.

- Socioeconomic sectors, terrestrial and aquatic ecosystems, and human health are sensitive to the magnitude and rate of climate change and the changes in climate extremes and variability;

- There are some beneficial effects, e.g., increased agricultural productivity at mid- and high-latitudes for small increases in temperature and reduced winter mortality.

- Most of the impacts are adverse, particularly in response to an increase in extreme weather events, with most natural systems and most people being adversely affected by climate change.

Natural Variability and Extremes

Table 1 Typology of Climate Extremes

Type	Description	Examples of Events	Typical Method of Characterization[a]
Simple extremes	Individual local weather variables exceeding critical level on a continuous scale	Heavy rainfall, high/low temperature, high wind speed	Frequency/return period, sequence and/or duration of variable exceeding a critical level
Complex extremes	Severe weather associated with particular climatic phenomena, often requiring a critical combination of variables	Tropical cyclones, drought, ice storms, ENSO-related events	Frequency/return period, magnitude, duration of variable(s) exceeding a critical level, severity of impacts
Unique or singular phenomena	A plausible future climatic state with potentially extreme large-scale or global outcomes	Collapse of major ice-sheets, cessation of thermohaline circulation, major circulation changes	Probability of occurrence and magnitude of impact

[a] Additionally, stakeholders can be engaged to define extreme circumstances via thresholds that mark a critical level of impact for the purposes of risk assessment. Such critical levels are often locally specific, so may differ between regions

Fig. 5 Extreme events

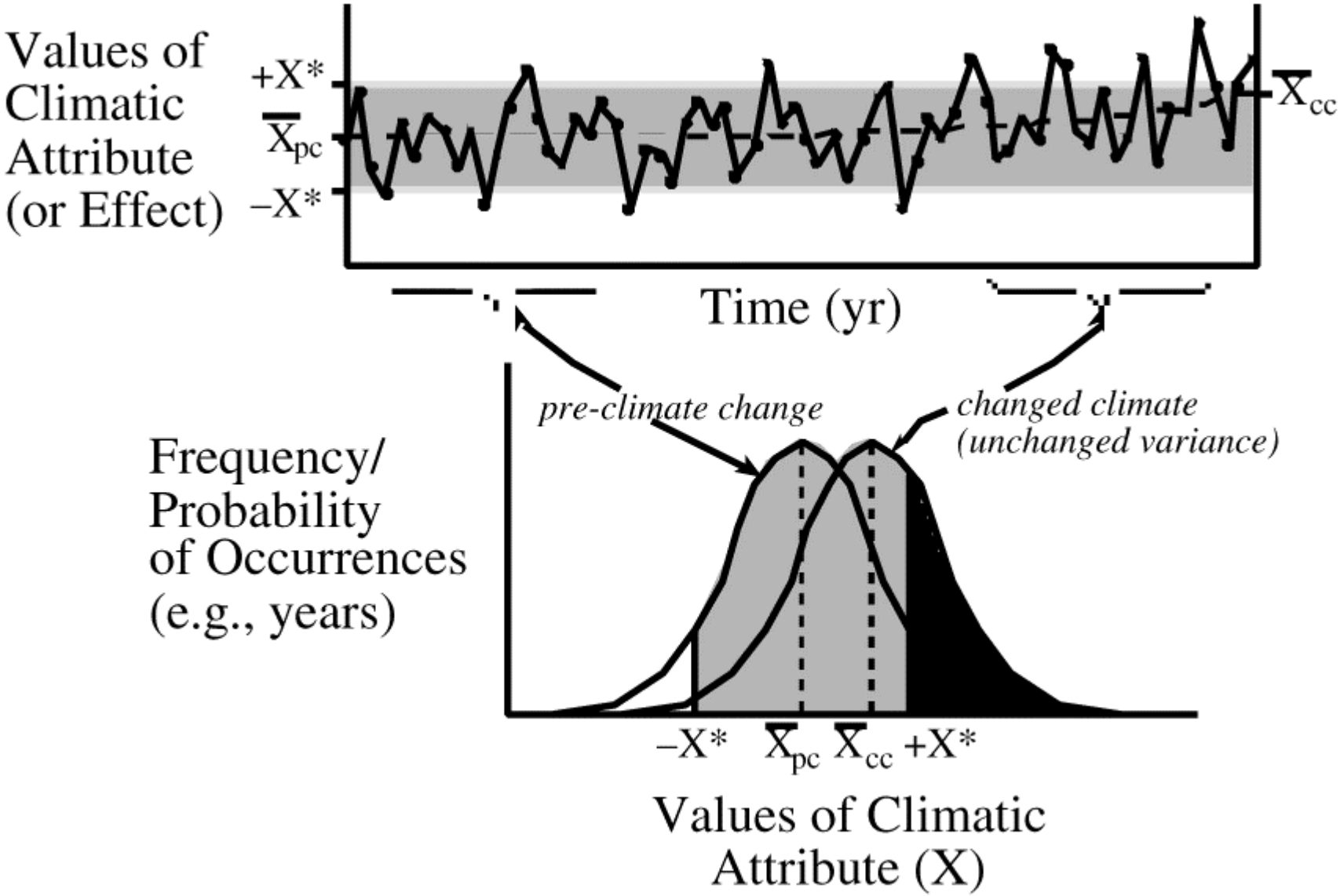


Table 2 Projected Changes in Extreme Climate Events and Resulting Impacts

Projected Changes during the 21st Century in Extreme Climate Phenomena and their Likelihood[a]	**Representative Examples of Projected Impacts**[b] **(all *high confidence* of occurrence in some areas**[c]**)**
Simple Extremes	
Higher maximum temperatures, more hot days and heat waves[d] over nearly all land areas (*Very likely*[e])	• Increased incidence of death and serious illness in older age groups and urban poor [4.7] • Increased heat stress in livestock and wildlife [4.2 and 4.3] • Shift in tourist destinations [Table TS-2 and 5.7] • Increased risk of damage to a number of crops [4.2] • Increased electric cooling demand and reduced energy supply reliability [Table TS-4 and 4.5]
Higher [Increasing] minimum temperatures, fewer cold days, frost days and cold waves[d] over nearly all land areas (*Very likely*[e])	• Decreased cold-related human morbidity and mortality [4.7] • Decreased risk of damage to a number of crops, and increased risk to others [4.2] • Extended range and activity of some pest and disease vectors [4.2 and 4.3] • Reduced heating energy demand [4.5]
More intense precipitation events (*Very likely*[e], over many areas)	• Increased flood, landslide, avalanche, and mudslide damage [4.5] • Increased soil erosion [5.2.4] • Increased flood runoff could increase recharge of some floodplain aquifers [4.1] • Increased pressure on government and private flood insurance systems and disaster relief [Table TS-4 and 4.6]

Table 2 (Cont.) Projected Changes in Extreme Climate Events and Resulting Impacts

Complex Extremes	
Increased summer drying over most mid-latitude continental interiors and associated risk of drought (*Likely*[c])	• Decreased crop yields [4.2] • Increased damage to building foundations caused by ground shrinkage [Table TS-4] • Decreased water resource quantity and quality [4.1 and 4.5] • Increased risk of forest fire [5.4.2]
Increase in tropical cyclone peak wind intensities, mean and peak precipitation intensities (*Likely*[c], over some areas)[e]	• Increased risks to human life, risk of infectious disease epidemics and many other risks[4.7] • Increased coastal erosion and damage to coastal buildings and infrastructure [4.5 and 7.2.4] • Increased damage to coastal ecosystems such as coral reefs and mangroves [4.4]
Intensified droughts and floods associated with El Niño events in many different regions (*Likely*[c]) [See also under droughts and intense precipitation events]	• Decreased agricultural and rangeland productivity in drought- and flood-prone regions [4.3] • Decreased hydro-power potential in drought-prone regions [5.1.1 and Figure TS-7]
Increased Asian summer monsoon precipitation variability (*Likely*[c])	• Increase in flood and drought magnitude and damages in temperate and tropical Asia [5.2.4]
Increased intensity of mid-latitude storms (Little agreement between current models)[d]	• Increased risks to human life and health [4.7] • Increased property and infrastructure losses [Table TS-4] • Increased damage to coastal ecosystems [4.4]

Fig.6 Cost of Extreme Events

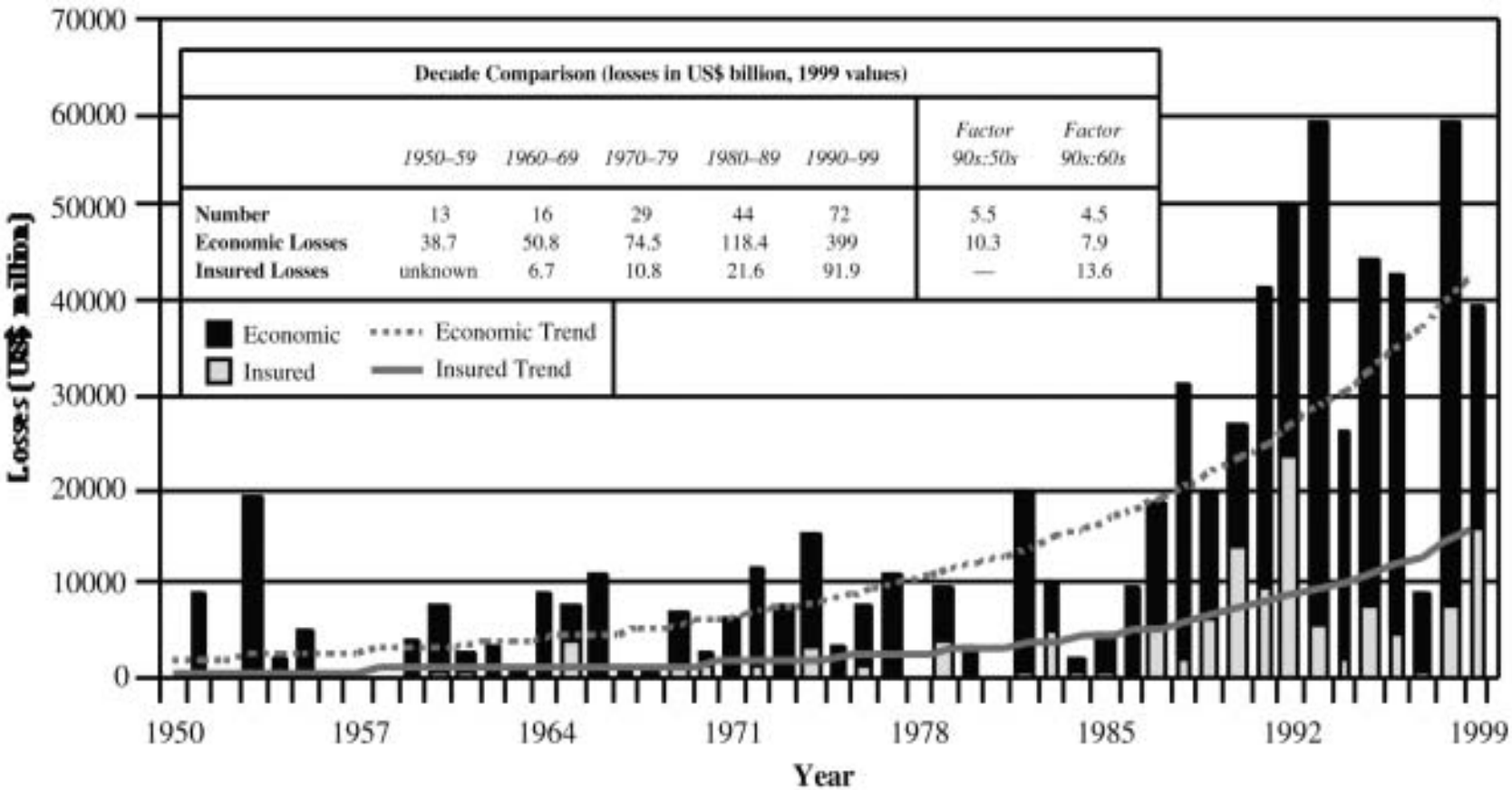
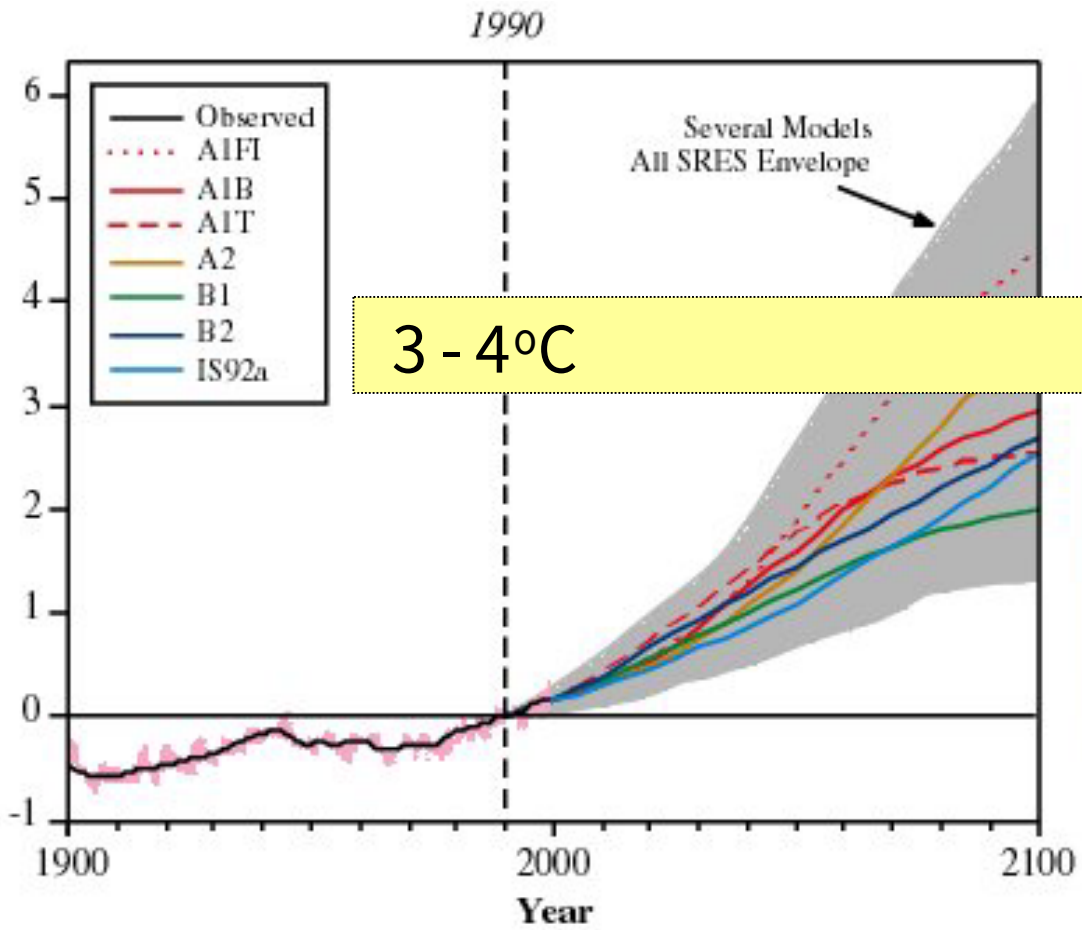


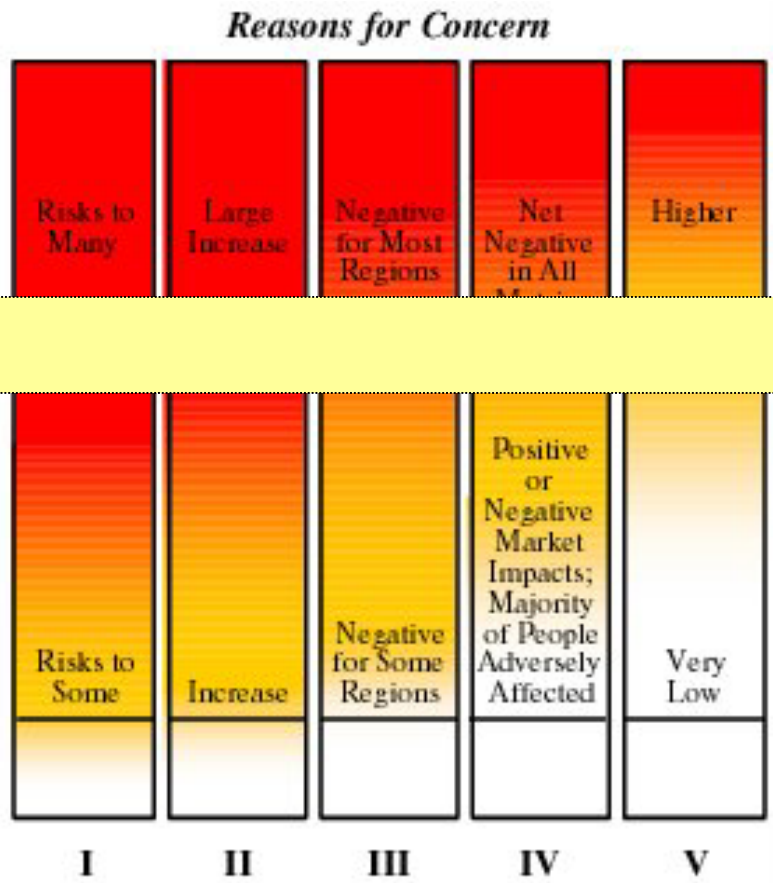
Figure TS-6: The costs of extreme weather events have exhibited a rapid upward trend in recent decades. Yearly economic losses from large events increased ten-fold from US$4 billion in the 1950s to US$40 billion per year in the 1990s (all in 1999 US$). The insured portion of these losses rose from a negligible level to US$ 9 billion annually during the same period, and the ratio of premiums to catastrophe losses fell by two-thirds. Notably, the costs are a factor of two larger when losses from small, non-catastrophic weather-related events are included. The numbers generally include "captive" self-insurers, but not the less formal types of self-insurance.

Synthesis

Fig.7 5 Reasons of Concerns



3 - 4°C



I	Risks to Unique and Threatened Systems
II	Risks from Extreme Climate Events
III	Distribution of Impacts
IV	Aggregate Impacts
V	Risks from Future Large-Scale Discontinuities

Most impact studies have assessed how systems would respond to only small changes in temperature, i.e., **less than 3-4°C**, which is less than the upper end of the projections using the SRES projections.

Adaptation

Developing countries are more vulnerable to climate change than developed countries:

(i) Human-induced climate change is an important new stress, particularly on ecological and socio-economic systems that are already affected by pollution, increasing resource demands, and non-sustainable management practices;

(ii) The most vulnerable systems are those with the greatest sensitivity to climate change and the least adaptability;

(iii) Most systems are sensitive to both the magnitude and rate of climate change, and in particular changes in climate extremes;

(iv) Successful adaptation depends upon technological advances, institutional arrangements, availability of financing and information exchange, and that vulnerability increases as adaptive capacity decreases.

Adaptation

- **The range of adaptation options for managed systems such as agriculture and water supply is generally increasing because of technological advances. However, developing countries have limited access to these technologies and appropriate information:**

- **The efficacy and cost-effectiveness of adaptation strategies will depend upon cultural, educational, managerial, institutional, legal and regulatory practices that are both domestic and international in scope.**

- **Incorporation of climate change concerns into resource-use and development decisions and plans for regularly scheduled investments in infrastructure will facilitate adaptation.**

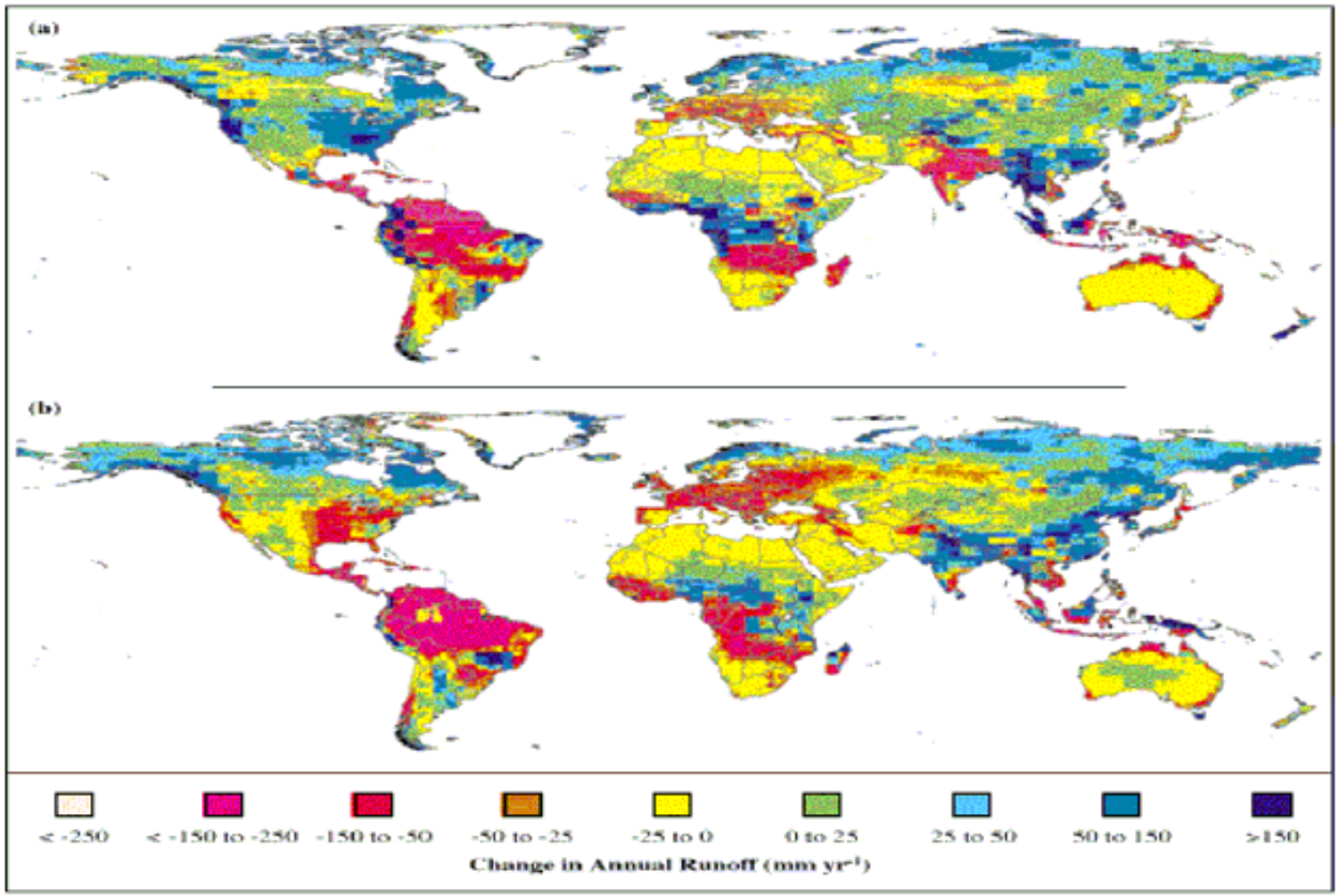
Water Resources: **Climate change could exacerbate water stress in many arid and semi-arid areas:**

- **Now 1.3 billion people do not have access to adequate supplies of clean water, and 2 billion people do not have access to adequate sanitation.**

- **19countries, primarily in the Middle East and Africa, are classified as water-scarce or water-stressed. Even in the absence of climate change, this number is expected to more than double by 2025, in large part because of increases in demand from economic and population growth.**

- **In many regions of the world a significant amount of water is wasted, largely through inefficient irrigation in the agricultural sector.**

Fig. 8 Runoff is projected to increase in some areas but decrease in others, especially in the sub-tropics



Water Resources:

- Projected changes in run-off from two different versions of the UK climate model show increases in run-off in high latitudes and south east Asia, and decreases in central Asia, the area around the Mediterranean, southern Africa and Australia. For other areas in the world, changes in run-off are model dependent.

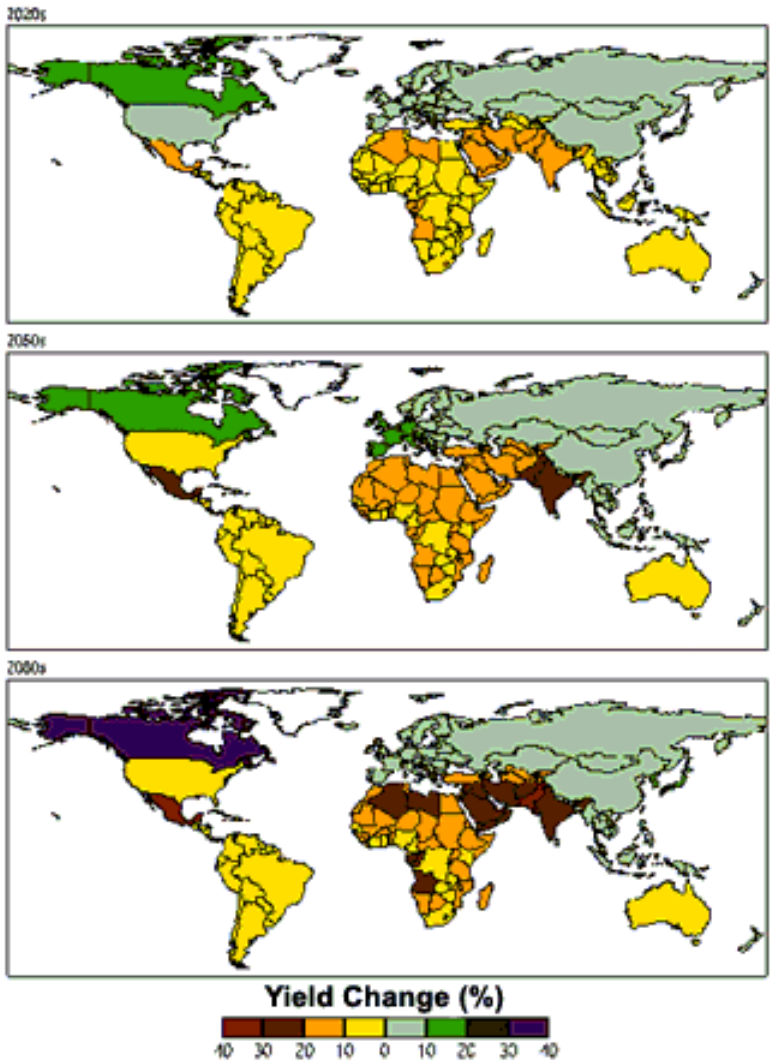
- Climate change could further exacerbate the frequency and magnitude of droughts in some places where droughts are already a recurrent feature. Developing countries are highly vulnerable to climate change because many are located in arid and semi-arid areas.

Agricultural Productivity and Food Security :Agricultural productivity is projected to decrease in many countries in the tropics and sub-tropics for almost any increase in temperature, but increase at mid- and high-latitudes for increases in temperature of up to a few ^{o}C:

- 800 million people are malnourished. As the world's population increases and incomes in some countries rise, food consumption is expected to double over the next three to four decades.

- Global agricultural production could be maintained relative to baseline production for global mean surface temperature changes of a few (2-3)^{o}C. However, crop yields and changes in productivity due to climate change will vary considerably across regions and among localities, thus changing the patterns of production.

Fig. 9 Crop yields are projected to decrease throughout the tropics and sub-tropics, but increase at high latitudes



Percentage change in average crop yields for the climate change scenario. Effects of CO_2 are taken into account. Crops modeled are: wheat, maize and rice.

Jackson Institute, University College London / Goddard Institute for Space Studies / International Institute for Applied Systems Analysis

Agricultural Productivity and Food Security :

- Productivity is projected to increase in middle to high latitudes, depending on crop type, growing season, changes in temperature regime, and seasonality of precipitation for small changes in temperature, but to **decrease in mid-latitudes** with temperature changes above 2-3^{o}C.

- **In the tropics and subtropics**, where some crops are near their maximum temperature tolerance and where dryland, non-irrigated agriculture dominates, yields are likely to decrease for even small increases in temperature, especially in Africa and Latin America, where decreases in overall agricultural productivity of up to 30% are projected during the next century. There may be increased risk of hunger in some locations in the tropics and subtropics where many of the world's poorest people live.

Natural Ecosystems :

- **Biological systems have already been affected in many parts of the world by changes in climate, particularly increases in regional temperature, during the last several decades:**

- **Climate change is projected to alter the composition and productivity of ecological systems and decrease biological diversity:**

Forests are vulnerable to projected changes in climate:

- **The distribution of forests and forest species are projected to change in response to changes in temperature, precipitation, extreme events, pest outbreaks and fires, altering the ecosystem goods and services provided.**

- **Boreal systems are likely to be the most vulnerable, primarily due to changes in fire and pest outbreaks, potentially leading to forest die-back, a change in age structure and a decrease in carbon content.**

- **The current net global terrestrial uptake of carbon (about 1GtC yr^{-1}) will likely increase during the first half of the 21st Century, and then level off or decline over time. Forest systems may even become a source of carbon by the end of the next of the 21st century.**

Coral reefs are threatened by increases in temperature:

- **Coral reefs are already being threatened by pollution, unsustainable tourism and fishing practices, are very vulnerable to changes in climate.**

- **While these systems may be able to adapt to the projected increases in sea level, sustained increases in water temperatures of 3-4^{o}C above long-term average seasonal maxima over a 6-month period can cause significant coral mortality**

- **Short-term increases on the order of only 1-2 ^{o}C can cause "bleaching", leading to reef destruction.**

Human Health:

Human health is sensitive to changes in climate because of its impact, in particular, on changes in water supply and quality, food security and the functioning and range of ecological systems:

- **Direct health effects would include increases in heat-related mortality and illness resulting from an anticipated increase in heatwaves, although offset to some degree in temperate regions by reductions in winter mortality.**

- **Indirect effects would include extensions of the range and season for vector organisms, thus increasing the likelihood of transmission of vector-borne infectious diseases (e.g., malaria, dengue, yellow fever and encephalitis).**

Table 3 Vector-borne Disease

Disease	*Vector*	*Population at risk (millions)*	*Present distribution*	*Likelihood of altered distribution with warming*
Malaria	mosquito	2,100	(sub)tropics	✓✓
Schistosomiasis	water snail	600	(sub)tropics	✓✓
Filariasis	mosquito	900	(sub)tropics	✓
Onchocerciasis (river blindness)	black fly	90	Africa/Latin America	✓
African trypanosomiasis (sleeping sickness)	tsetse fly	50	tropical Africa	✓
Dengue	mosquito	unavailable	tropics	✓✓
Yellow fever	mosquito	unavailable	tropical South America & Africa	✓

Likely ✓
Very likely ✓✓

Source: **Modified WHO, as cited in Stone (1995).**

Human Health:

- Projected climate changes could lead to an increase in the number of people at risk of malaria of the order of tens of millions annually, primarily in tropical, subtropical, and less well protected temperate-zone populations .

- Some increases in non-vector-borne infectious diseases such as salmonellosis, cholera and other food- and water-related infections could also occur, particularly in tropical and subtropical regions, because of climatic impacts on water distribution and temperature, and on micro-organism proliferation.

- The impacts of climate change on food production within food-insecure regions and the consequences of economic dislocation and demographic displacement (e.g., sea level rise) would have wide-ranging health impacts.

Sea Level Rise: Sea-level rise is projected to have negative impacts on human settlements, tourism, freshwater supplies, fisheries, exposed infrastructure, agricultural and dry lands, and wetlands, causing loss of land, economic losses and the displacement of tens of millions of people:

- About half of the world's population lives in coastal zones. Climate changesi will affect coastal systems through sea-level rise and an increase in storm-surge hazards and possible changes in the frequency and/or Intensity of extreme events.

- Impacts may vary across regions, and societal costs will greatly depend upon the vulnerability of the coastal system and the economic situation of the country. Sea-level rise will increase the vulnerability of coastal populations to flooding.

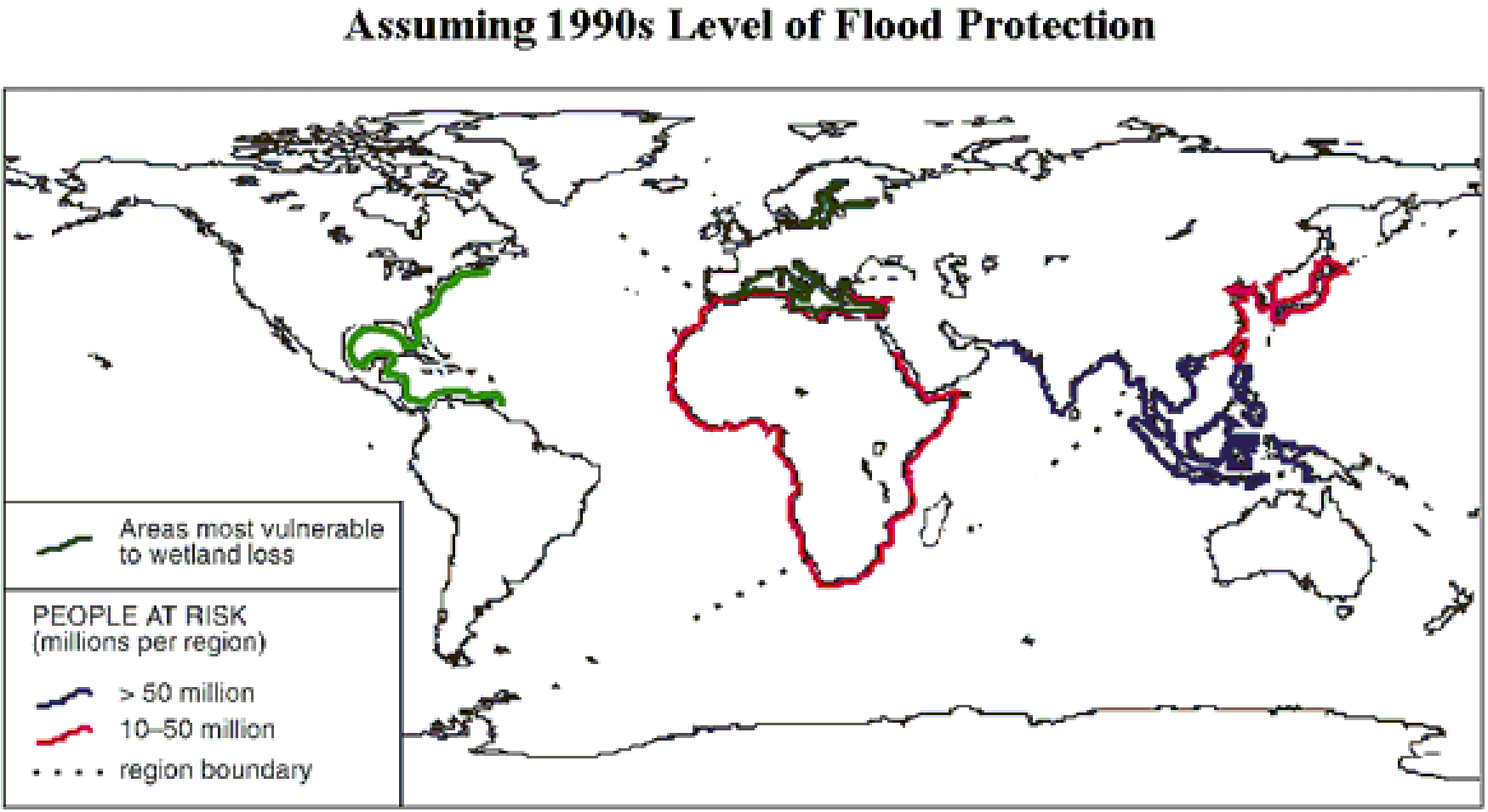
Sea Level Rise:

- **An average of about 46 million people per year currently experience flooding due to storm surges; a 50 cm sea-level rise would increase this number to about 92 million; a 1 meter sea-level rise would increase this number to 118 million. A number of studies have shown that small islands and deltaic areas are particularly vulnerable to a one-meter sea-level rise.**

- **In the absence of mitigation actions (e.g., building sea walls), land losses are projected to range from 1.0% for Egypt, 6% for Netherlands, 17.5% for Bangladesh, to about 80% of the Marshall Islands, displacing tens of millions of people.**

- **Many nations face lost capital value in excess of 10% of GDP. While annual adaptation/protection costs for most of these nations are relatively modest (about 0.1% GDP), average annual costs to many small island states are much higher, several percent of GDP, assuming adaptation is possible.**

Fig. 10 Tens of millions of people are projected to be at risk of being displaced by SLR



Source: R. Nicholls, Middlesex University in the U.K. Meteorological Office. 1997. *Climate Change and Its Impacts: A Global Perspective.*

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Fig. 11 Regions for the IPCC Working Group 2 Third Assessment Report

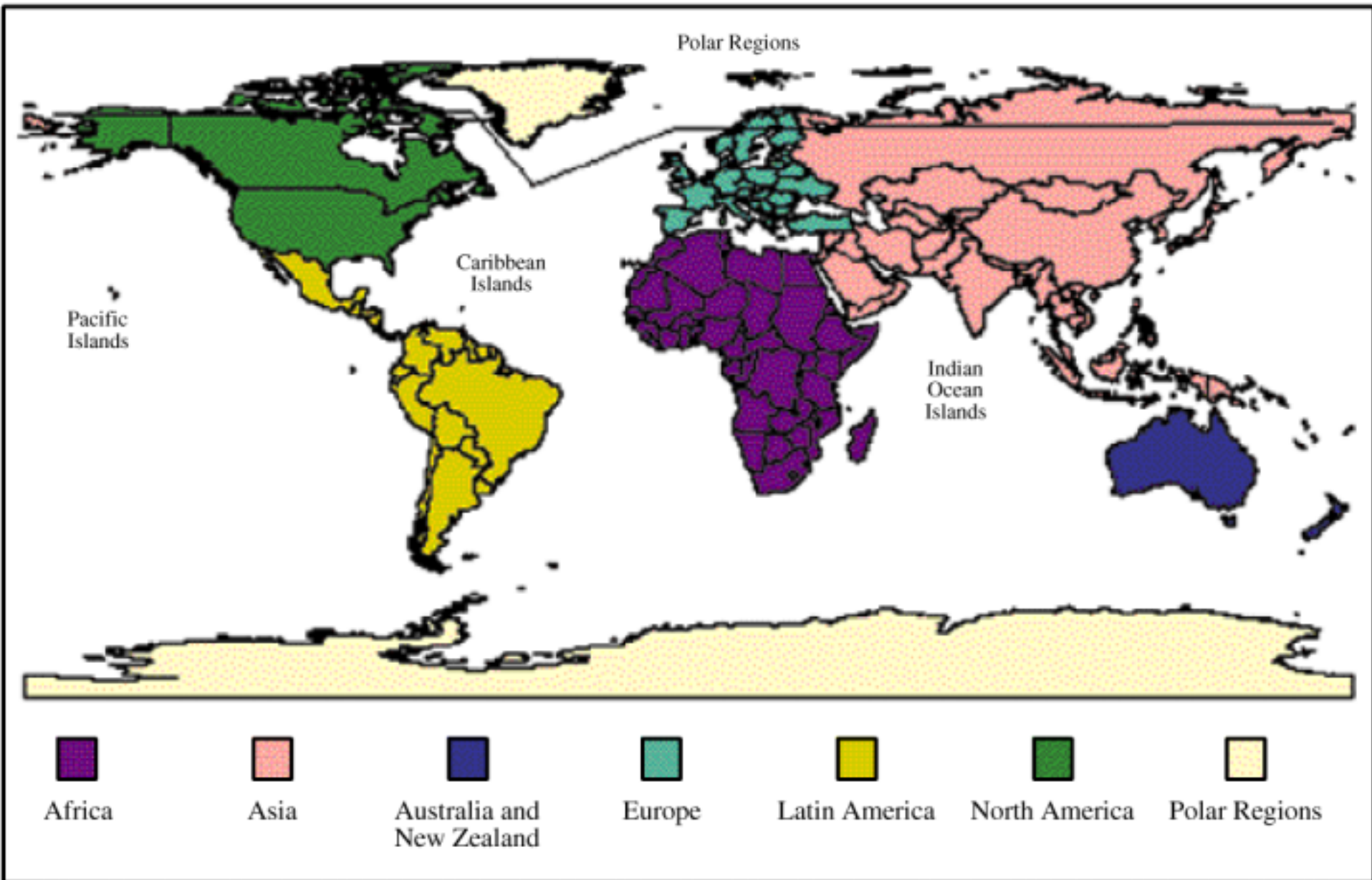

Table 4 Number of Persons Who have contributed to IPCC TAR

	WG 1	WG 2	WG 3	Total
Coordinating Lead Author (CLA) and Lead Author (LA)	122(4)[a)]	183(7)[a)]	150(12)[a)]	455(23)[a)]
Coordinating Author (CA)	516	243	80	839
Reviewer (including Government Reviewer)	337	440	>300	>1077
Review Editor (RE)	21(1)[a)]	33	18(2)[a)]	72(2)[a)]
Total	996	899	>548	>2443

a：（）：Number of Japanese CLAs, LAs, and REs.

Fig.12 Sub-regions of Asia in TAR

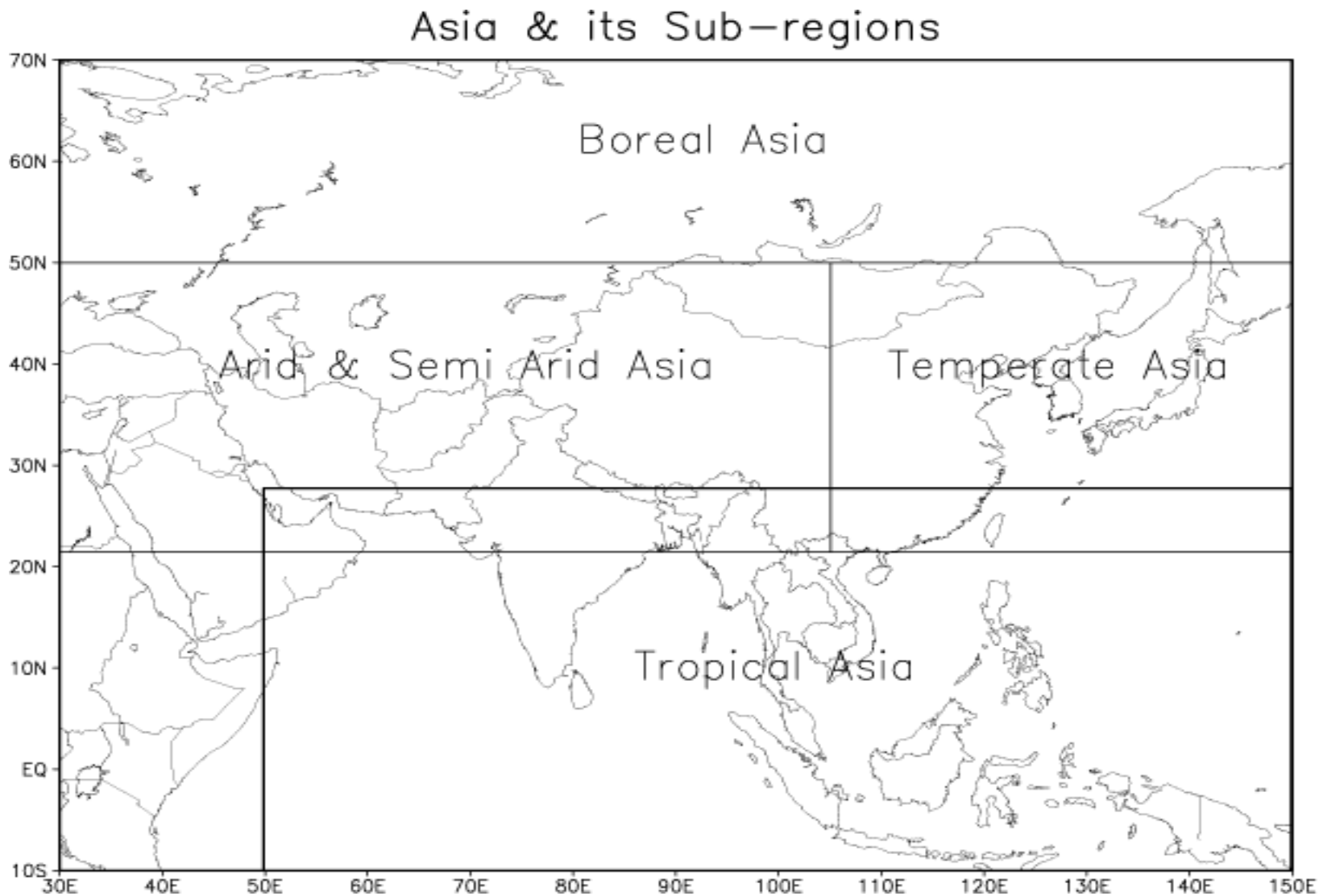

Table 5 Vulnerability of Key Sectors in Asian Region

Sub-regions	Food & Fibre	Bio-diversity	Water Resource	Coastal Ecosystem	Human Health	Settlements
Boreal Asia	+1 / H	-2 / M	+1 / M	+1 / L	-1 / L	0 / M
Arid & Semi Arid Asia						
-Central Asia	-2 / H	-1 / L	-2 / H	-1 / L	-1 / M	-1 / M
-Tibetan Plateau	0 / L	-2 / M	-1 / L	Not applicable	No information	No information
Temperate Asia	-2 / H	-1 / M	-2 / H	-2 / H	-2 / M	-2 / H
Tropical Asia						
-South Asia	-2 / H	-2 / M	-2 / H	-2 / H	-1 / M	-2 / M
-S-E Asia	-2 / H	-2 / M	-2 / H	-2 / H	-1 / M	-2 / M

Vulnerability:

-2 – Highly vulnerable
-1 – Moderately vulnerable
0 – Slightly or Not vulnerable
+1 – Slightly resilient
+2 – Most resilient

Level of Confidence:

VH - Very High
H - High
M - Medium
L - Low
VL - Very Low

Adaptive Capacity, Vulnerability and Key Concerns in Asian Region

• **Adaptive capacity** of human systems is low and vulnerability is high in the developing countries of Asia; the developed countries of Asia are more able to adapt and less vulnerable. [5.2.7]

• **Extreme events** have increased in temperate and tropical Asia, including floods, droughts, forest fires, and tropical cyclones *(high confidence)*. [5.2.4]

• Decreases in **agricultural productivity and aquaculture** due to thermal and water stress, sea-level rise, floods and droughts, and tropical cyclones would diminish food security in many countries of arid, tropical, and temperate Asia; agriculture would expand and increase in productivity in northern areas *(medium confidence)*. [5.2.1]

• **Runoff and water availability** may decrease in arid and semi-arid Asia but increase in northern Asia *(medium confidence)*. [5.2.3]

• **Human health** would be threatened by possible increased exposure to vector-borne infectious diseases and heat stress in parts of Asia (*medium confidence)*. [5.2.6]

• **Sea-level rise and an increase in the intensity of tropical cyclones** would displace tens of millions of people in low-lying coastal areas of temperate and tropical Asia; increased intensity of rainfall would increase flood risks in temperate and tropical Asia *(high confidence)*. [5.2.5 and Table TS-8]

• Climate change would increase **energy demand**, decrease **tourism attraction**, and influence **transportation** in some regions of Asia *(medium confidence)*. [5.2.4 and 5.2.7]

• Climate change would exacerbate threats to **biodiversity** due to land-use and land-cover change and population pressure in Asia *(medium confidence)*. Sea-level rise would put **ecological security** at risk, including mangroves and coral reefs *(high confidence)*. [5.2.2]

• Poleward movement of the southern boundary of the **permafrost zones** of Asia would result in a change of thermokarst and thermal erosion with negative impacts on social infrastructure and industries *(medium confidence)* . [5.2.2]