「全球氣候變遷下的台灣」國際研討會, 遠景基金會

Impacts of Climate Change on Taiwan's Economy

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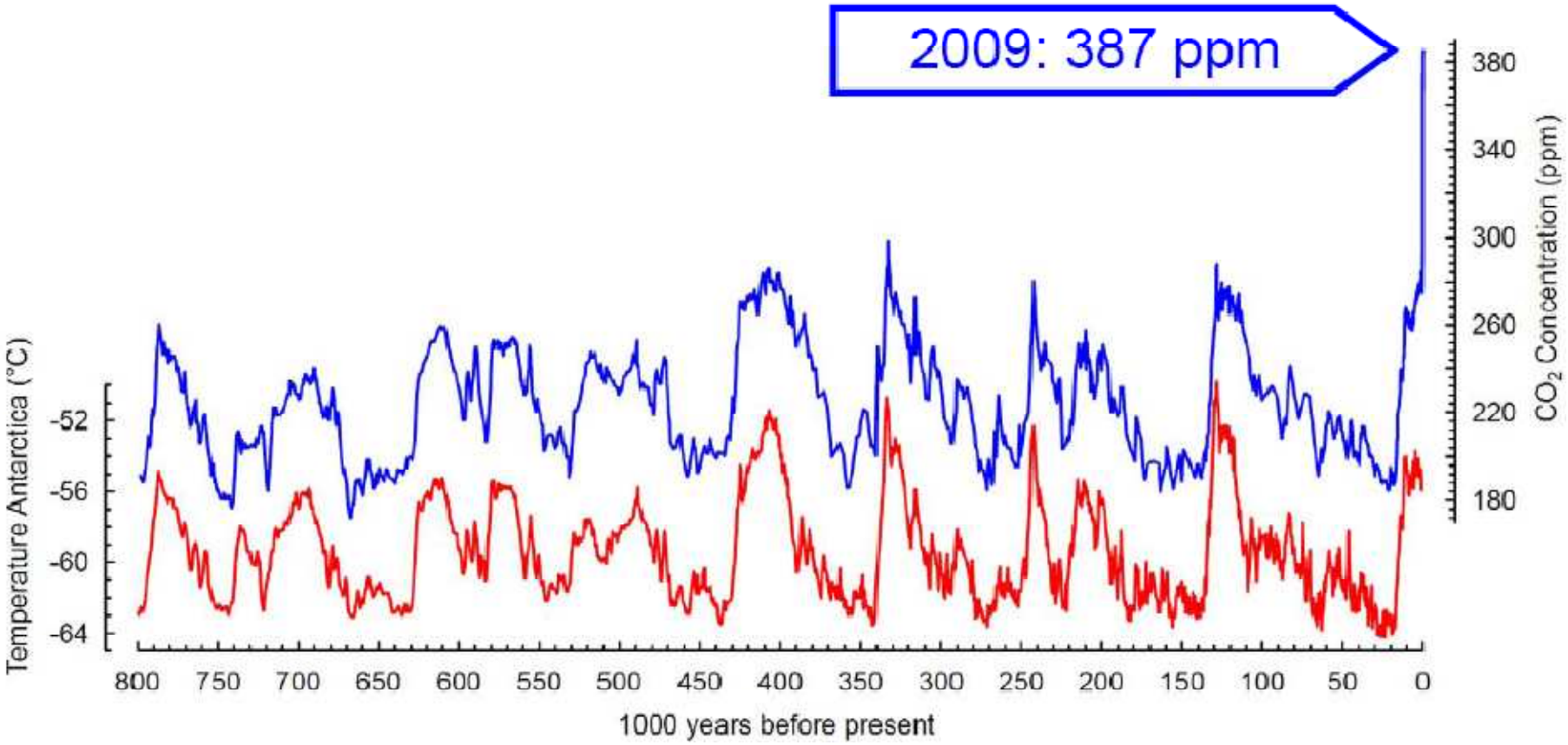
Outline

1. Latest Findings on Global Climate Change
2. Climate Change in Taiwan
3. Impacts of Climate Change on Taiwan
4. The Relationship Between the Impact and the Cost of Climate Change
5. Taiwan’s Response to Climate Change
6. Economic Impacts of Carbon Mitigation Policies
7. Taiwan's Climate Adaptation Policies
8. Conclusion

1. Latest Findings on Global Climate Change (1/4)

(1) CO_2 : Higher Levels with More Dramatic Increase



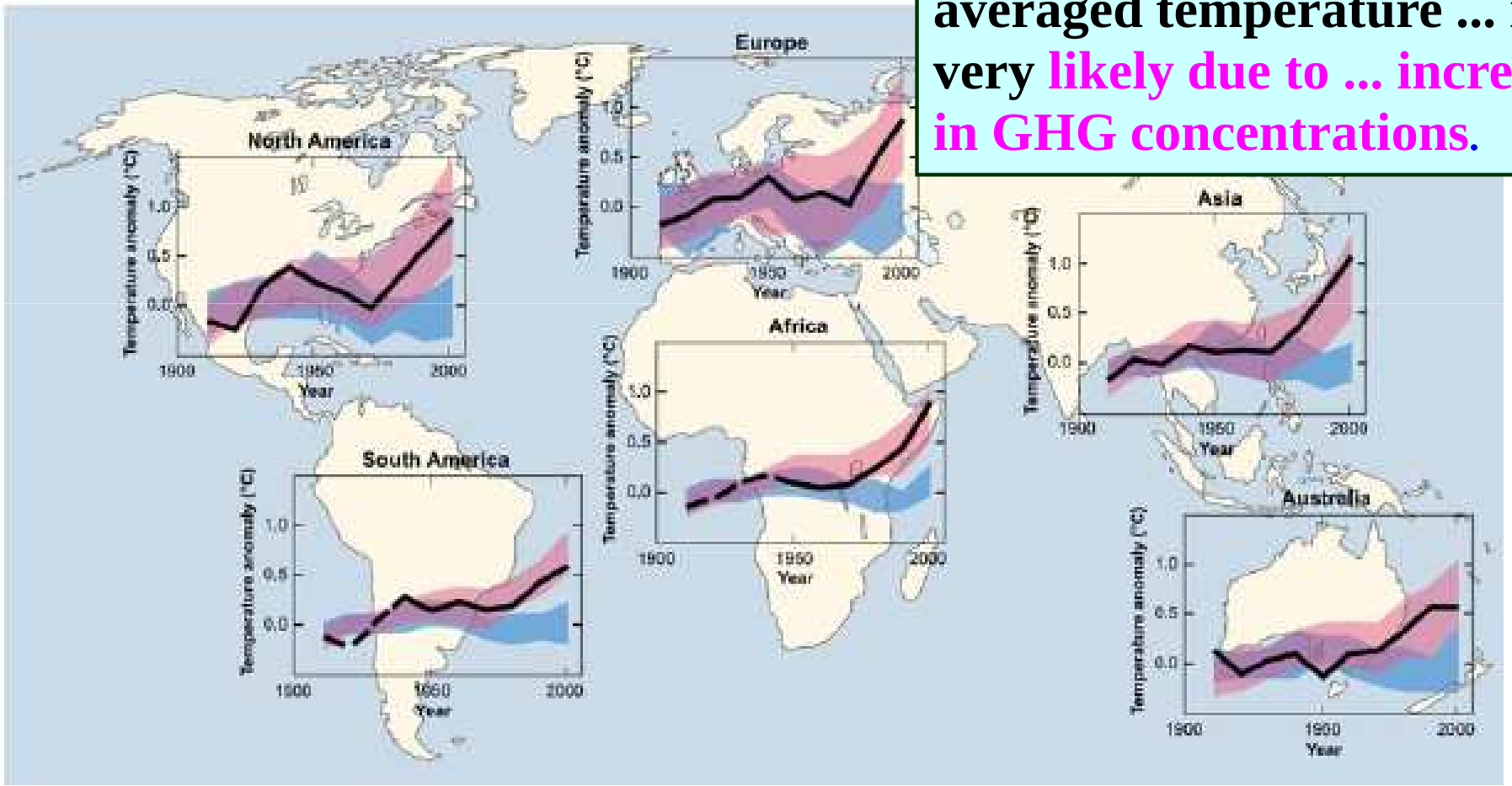
(Siegenthaler et al., 2005; Lüthi et al., 2008, NOAA)

Source: Thomas Stocker, "IPCC Findings and Activities and their Relevance for the UNFCCC Process—The Physical Science Basis of Climate Change: Latest Findings to be Assessed by WG I in AR5," IPCC Side Event, United Nations Climate Change Conference, COP 15, Copenhagen, Denmark, 8th December 2009.

1. Latest Findings on Global Climate Change (2/4)

(2) Global Warming

IPCC (2007): Most of the observed increase in global averaged temperature ... is very likely due to ... increase in GHG concentrations.

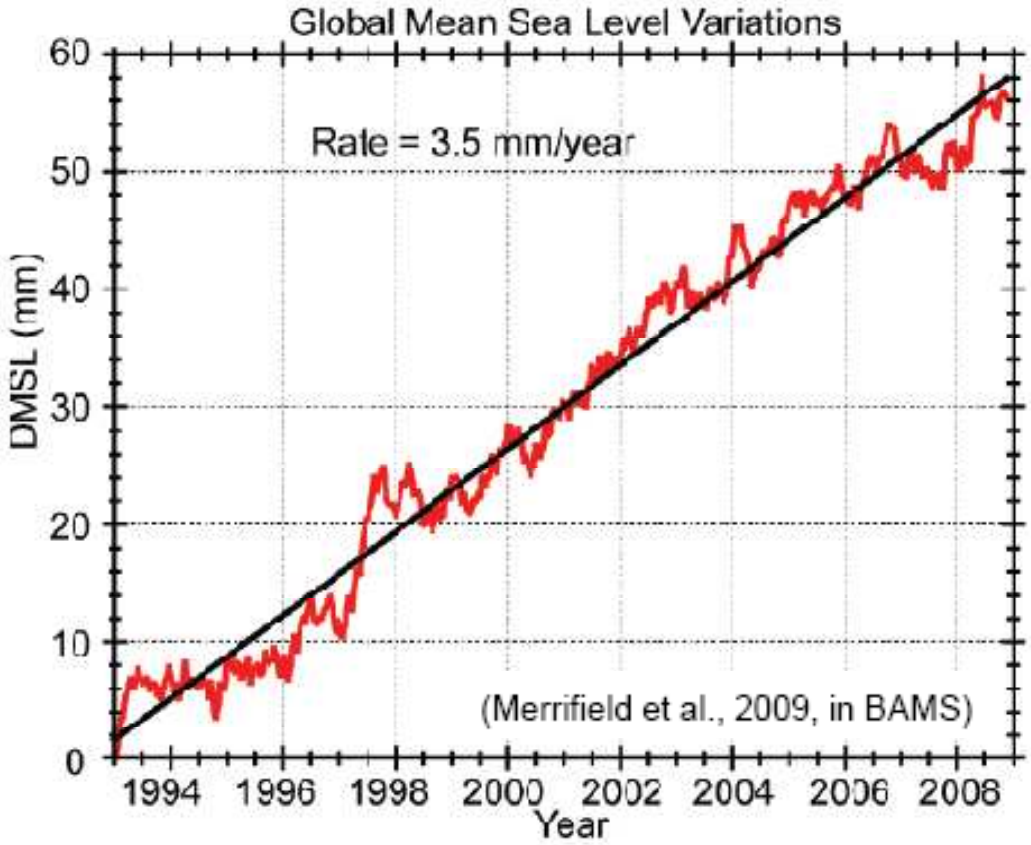


(IPCC, 2007, Fig. WGI-SPM-4)

Source: Thomas Stocker, "IPCC Findings and Activities and their Relevance for the UNFCCC Process—The Physical Science Basis of Climate Change: Latest Findings to be Assessed by WG I in AR5," IPCC Side Event, United Nations Climate Change Conference, COP 15, Copenhagen, Denmark, 8th December 2009.

1. Latest Findings on Global Climate Change (3/4)

(3) Sea Level : Persistent Sea-Level Rising



Merrifield et al., 2009:

[1993–2008] (3.5 ± 0.4) mm/yr

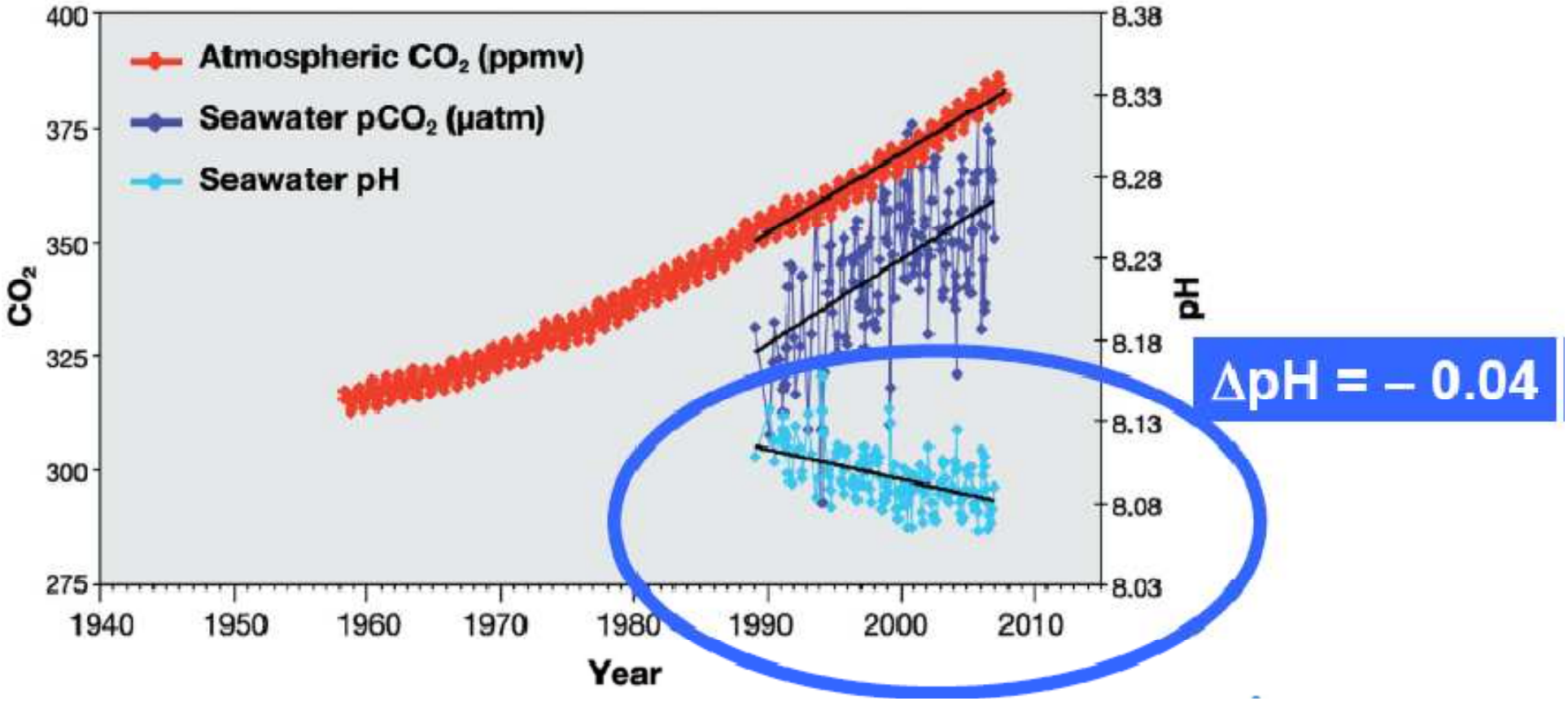
IPCC 2007:

[1993–2003] (3.1 ± 0.7) mm/yr

Source: Thomas Stocker, "IPCC Findings and Activities and their Relevance for the UNFCCC Process—The Physical Science Basis of Climate Change: Latest Findings to be Assessed by WG I in AR5," IPCC Side Event, United Nations Climate Change Conference, COP 15, Copenhagen, Denmark, 8th December 2009.

1. Latest Findings on Global Climate Change (4/4)

(4) Acidification of World Ocean Due to Increase of CO_2



Source: Thomas Stocker, "Scientific knowledge to meet the challenge of climate change—Policy-relevant results from AR4 and some latest findings to be assessed in AR5," IPCC Side Event, Barcelona Climate Change Talks 2009, Barcelona, Spain, 3 November 2009.

2. Climate Change in Taiwan (1/4)

（1）Temperature

1. In the past 100 years, **average temperature in Taiwan increased by 0.8℃** (globally by 0.74 ℃).
2. Temperature in neighboring sea increased by 0.9~1.1℃.
3. In the past 50 years, **frequency and length of heat waves have clearly increased**.

（2）Rainfall

1. The total rainfall has not significantly changed.
2. Although **raining hours shown decreased**, the **precipitation intensity** (precipitation per unit time) **has increased**.

Source: Taiwan's Central Weather Bureau, 「近百年來（1897-2008）台灣氣候變化統計報告」(the Statistics of Climate Changes in Taiwan: 1897-2008), December 2009.

2. Climate Change in Taiwan (2/4)

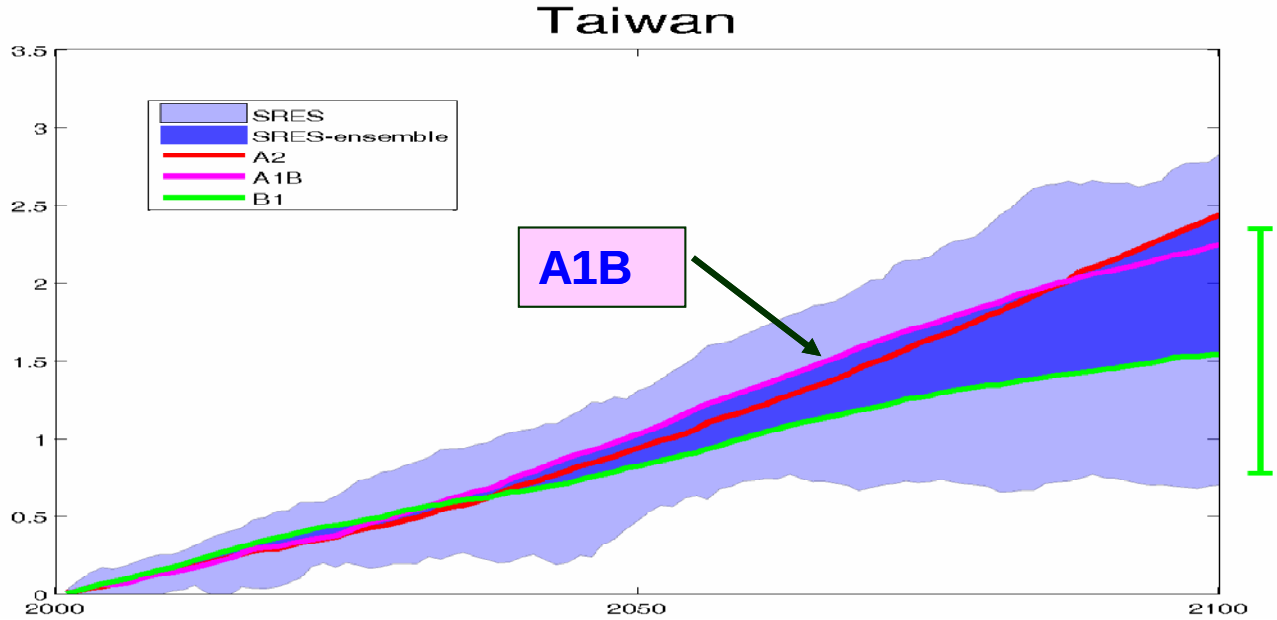
（3）Extreme Heavy Rainfall and Typhoons

1. **Over the past 40 years, the extreme rainfall from typhoons tended to occur approximately once every three or four years during the pre-2000 period and has increased in frequency to once a year since 2000.**

Source: Chen, Liang-Chun and Ben Jong-Dao Jou, "Extreme Climate Change and Environmental Risk in Taiwan," Reshaping the Global Risk Environment: Impact of Climate Change on Taiwan's Overall Security, Cross-Strait Interflow Prospect Foundation, October 2010.

2. Climate Change in Taiwan (3/4)

(4)Temperature Projection in Taiwan by the End of 21st Century



Under A1B Scenario of IPCC (rapid economic growth with a balanced emphasis on all energy sources)

a. **Average temperature is projected to increase by 2.3℃ (1.5~ 2.5℃).**

b. **Seasonal and spatial differences exist in Taiwan's future temperature increases.**

c. **High-temperature(≧32℃) days are projected to increase, and low-temperature (≦10℃) days are projected to decrease.**

(Source: Council for Economic Planning and Development, 2010)

2. Climate Change in Taiwan (4/4)

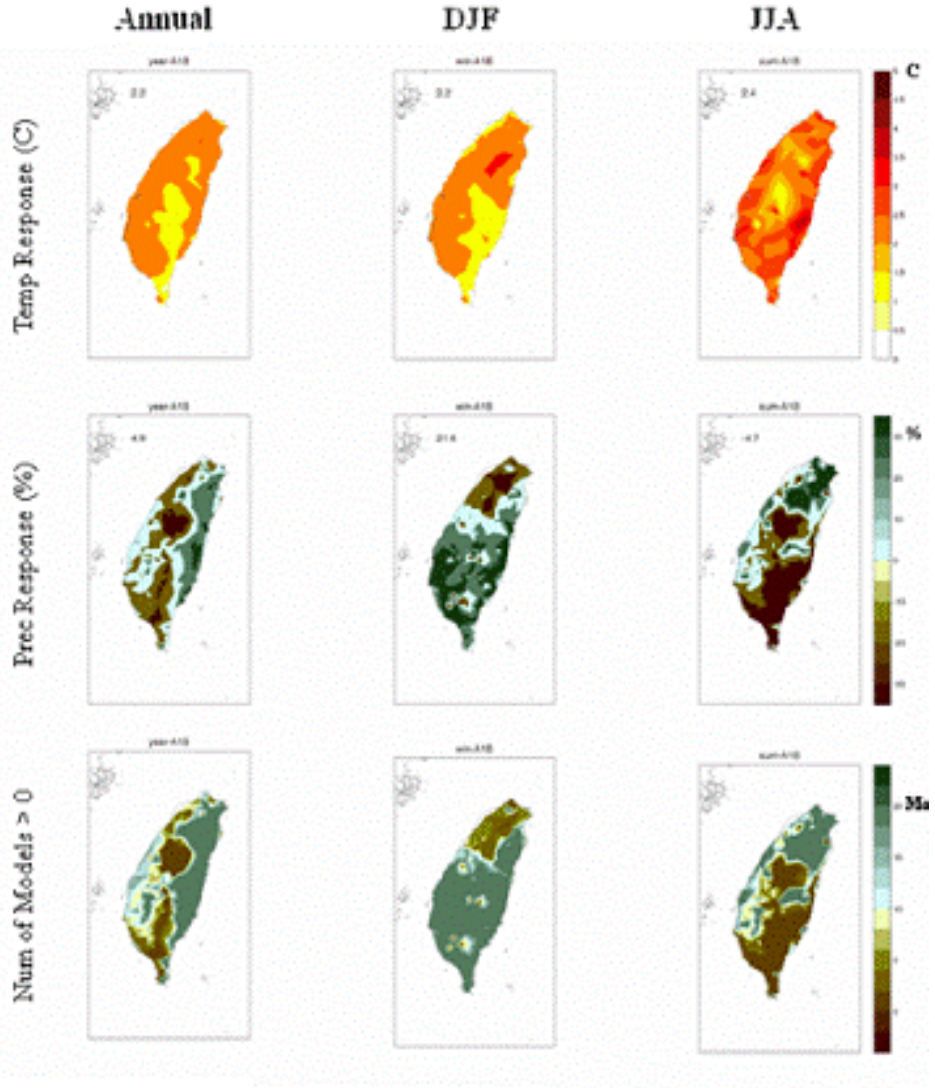
(5) Rainfall Projection in Taiwan by the End of 21st Century

a. **Average annual rainfall of areas close to Taiwan is projected to increase by 7%.**

b. **Proportion of heavy rainfall is projected to increase.**

c. **Number of rainless days during the drought seasons is projected to increase.**

(Source: Council for Economic Planning and Development, 2010)



3. Impacts of Climate Change on Taiwan (1/4)

(1) Major Potential Impacts

Disasters	•Rainfall intensity increases. Flooding, landslides and debris disasters also increase. Extreme rainfall typhoons increase in frequency, which creates a significant challenge to the disaster prevention systems.
Infrastructures	•Infrastructure (bridges, roads, reservoirs, transportation, energy, and water supply) hazards from heavy rain and water level rise vary in different regions.
Water Resources	•Temperature, rainfall patterns and hydrological characteristics change, which increases the risks of multiple disasters, affects irrigation, domestic, and industrial water consumptions and increases difficulties in water resources management. •Under extreme river flow, water quality is affected.
Land Use	•Extreme climate increases the vulnerability and sensitivity of the environment, underlining the importance of safe use of land resources.

3. Impacts of Climate Change on Taiwan (2/4)

(1) Major Potential Impacts (Continued)

Coast	• As sea level rises, the existing coast protection works, sceneries, and resources are destroyed, causing loss of territory.
Energy Supply and Industries	• Energy demand patterns and costs change, which makes supplying energy stably and meeting the peak-load demand difficulty. • Public and private facilities are impacted, which cause investment loss and increase in equipment cost.
Agriculture and Bio-diversity	• Increased temperature and insufficient rainfall disrupt crops' cycle. Both crops' quantity and quality become uncertain, risking food supply. Fishery is also affected. • Environmental changes also affect ecosystem, creating loss in bio-diversity.
Health	• Rising temperatures lead to vector spread and increase the possibility of epidemics. • Extreme weather increases the burden on public health and medical systems.

3. Impacts of Climate Change on Taiwan (3/4)

(2) Impacts on Industries

a. Impacts Due to Changes in Quality and Quantity of Water Supply

a) **Droughts and extreme rainfalls affect water supply and industrial operations although industries have aggressively adopted water conservation measures.**

b) **High water-consumption processes (ex. boiler operation, cooling and cleansing) in petrochemical, paper, textile, metal, and electronic industries are impacted significantly by the drought and heavy rainfall events.**

b. Impacts Due to Ambient Temperature Increase

a) **High ambient temperatures cause the decrease in energy efficiency and the increase in power demand for the cooling systems in industrial processes.**

b) **Refrigeration systems for wholesale, retail, and hospitality industries are sensitive to increasing temperatures.**

c) **Energy demands of air conditioning systems for manufacturing and service sectors increase, which impacts the power supply stability during summer peak-load periods.**

c. Impacts Due to Sea Level Rise

a) **Reliability of manufacturers' operations located in industrial zones along the coastal areas will be affected by rising sea level and coastal erosion.**

3. Impacts of Climate Change on Taiwan (4/4)

(2) Impacts on Industries (Continued)

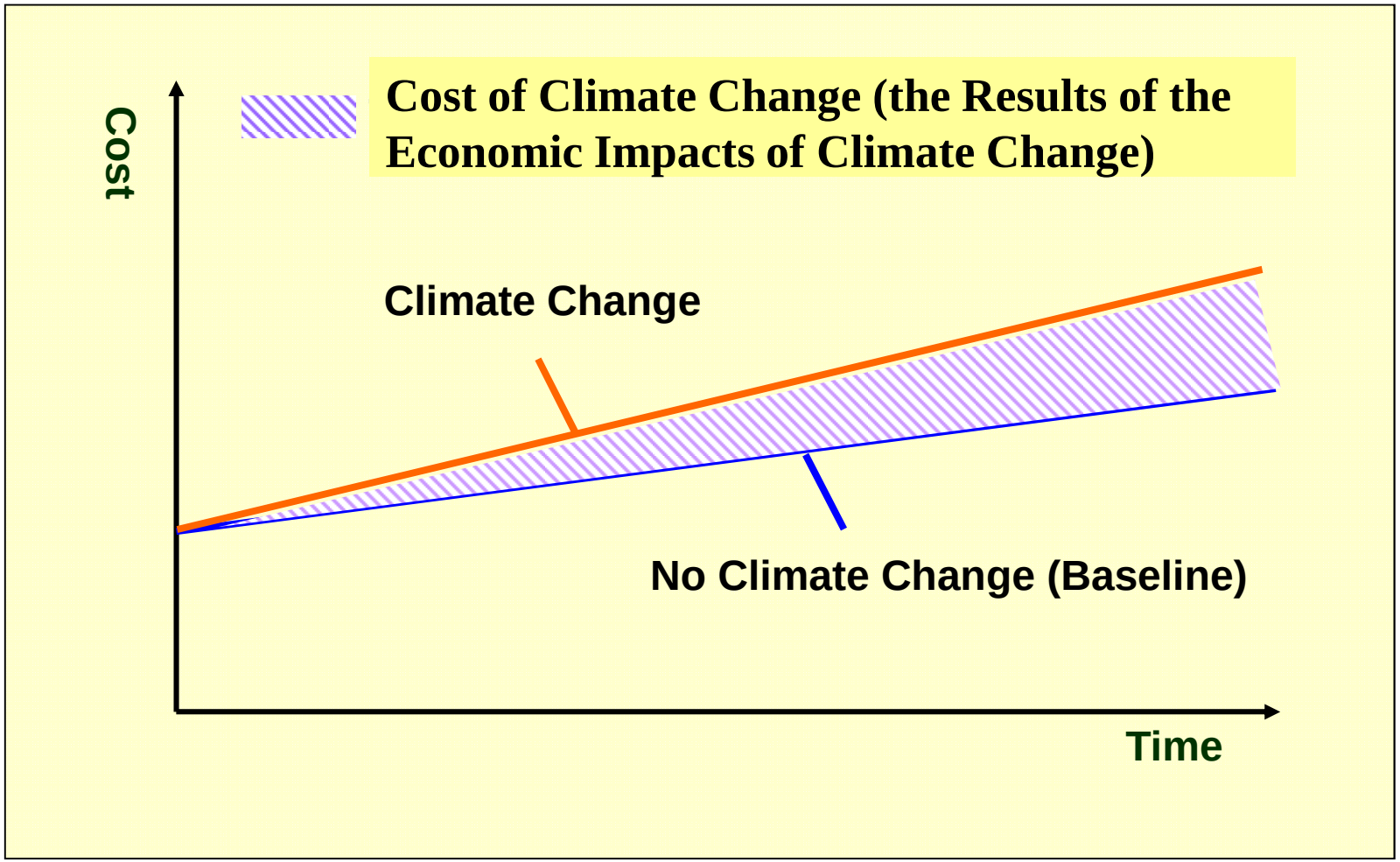
d. CO_2 Reduction Requirement

a) **In order to achieve the CO_2 emissions reduction goals set forth by the Government and comply with the global trend of carbon reduction, the Government needs to help the industry to build the capacity for carbon reduction.**

b) **Photovoltaic and LED electronic industries in Taiwan have an international advantage. The Government is currently promoting the "Sunrise Program for Green Energy Industry". Taiwan can grasp the opportunities for green energy to develop it into a trillion dollar industry.**

4. The Relationship Between the Impact and the Cost of Climate Change (1/11)

(1) Concept of Economic Impacts of Climate Change



4. The Relationship Between the Impact and the Cost of Climate Change (2/11)

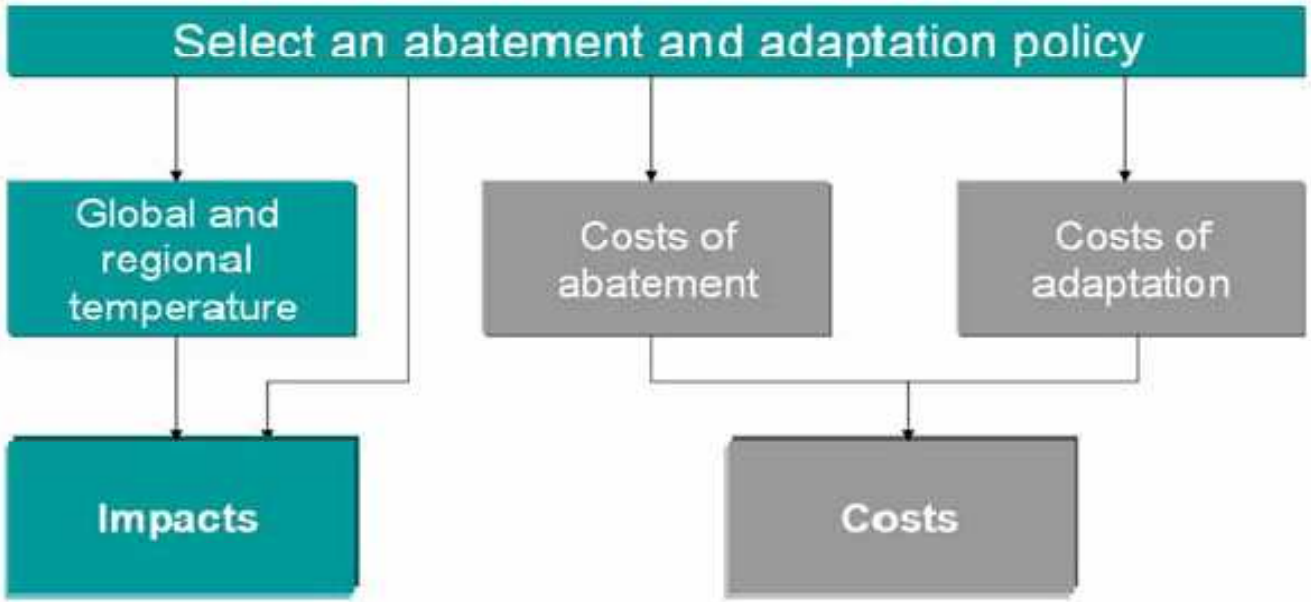
(2) Cost of Climate Change

- **Cost of climate change brought by increasing GHG concentrations in the atmosphere may gradually increase.**
- **Aggressive climate mitigation policies with greater GHG emissions reductions may have lower overall cost (higher mitigation cost but lower adaptation or damage cost).**
- **Inactive climate mitigation policies with low GHG emissions reductions may have higher overall cost of climate change (lower mitigation cost but higher adaptation or damage cost).**

4. The Relationship Between the Impact and the Cost of Climate Change (3/11)

(3) Impacts of Climate Change on Global Economy

a. PAGE2002 Model Structure for UK Stern Review Report (2006)



4. The Relationship Between the Impact and the Cost of Climate Change (4/11)

(3) Impacts of Climate Change on Global Economy(Continued)

b. Global Economic Costs from Climate Change (UK Stern Review Report, 2006)

- **Costs of extreme weather alone can reach 0.5-1% of global GDP per annum by the middle of the century and will keep rising if temperature continues to increase.**
- **If temperature increases by 5-6˚C, existing models estimate an average of 5-10% loss in global GDP, with poor countries losing in excess of 10% of the GDP.**
- **Climate change will reduce welfare by an equivalent of a reduction between 5 and 20% in consumption per head.**

Source: Nicholas Stern, "The Stern Review on the Economics of Climate Change," London, UK: Her Majesty's Treasury, October 30, 2006

4. The Relationship Between the Impact and the Cost of Climate Change (5/11)

(4) Impacts of Climate Change on Taiwan's Economy

a. Economic Assessment of Climate Change's Impact on Taiwan's Ecosystem

(Dr. Daigee Shaw, the Chung-Hua Institution for Economic Research, 2009)

Unit：Million NT$/Year

Area	SRES A2			SRES B2		
	Short-term	Mid-term	Long-term	Short-term	Mid-term	Long -term
Biodiversity	Total Loss: NT$ 6.9 trillions			Total Loss: NT$ 5.8 trillions		
Forest	-3	2	0.3	2	3	-4
	-2	0.8	0.05	0.7	0.8	-1
Agriculture	148	-	597	-	-	-
Fishing	-4	4	-21	-	-	-

Note：1. Positive denotes benefit; negative denotes loss.

2. Short bar (-) indicates no estimation was made possibly because there is no model data or simply not significant enough.
3. SRES: Special Report on Emissions Scenarios published by IPCC in 2001. A2: High degree of population growth and primarily regional economic growth; B2: Economically, socially, and environmentally sustainable scenario.
4. Short-term:2010~2039；mid-term:2040~2069；long-term:2070~2099.

4. The Relationship Between the Impact and the Cost of Climate Change (6/11)

(4) Impacts of Climate Change on Taiwan's Economy

a. Economic Assessment of Climate Change's Impact on Taiwan's Ecosystem (Continued)

Unit：Million NT$/Year

Area	SRES A2			SRES B2		
	Short-term	Mid-term	Long-term	Short-term	Mid-term	Long-term
Public Health	-	-4148~ -4630	1286~ 1435	-	-2129~ -2376	-789 ~ -880
	-	-13618	-82283	-	-9265	-52253
Human Health	-	-6	-130	-	-40	-77

Note：1. Positive denotes benefit; negative denotes loss.

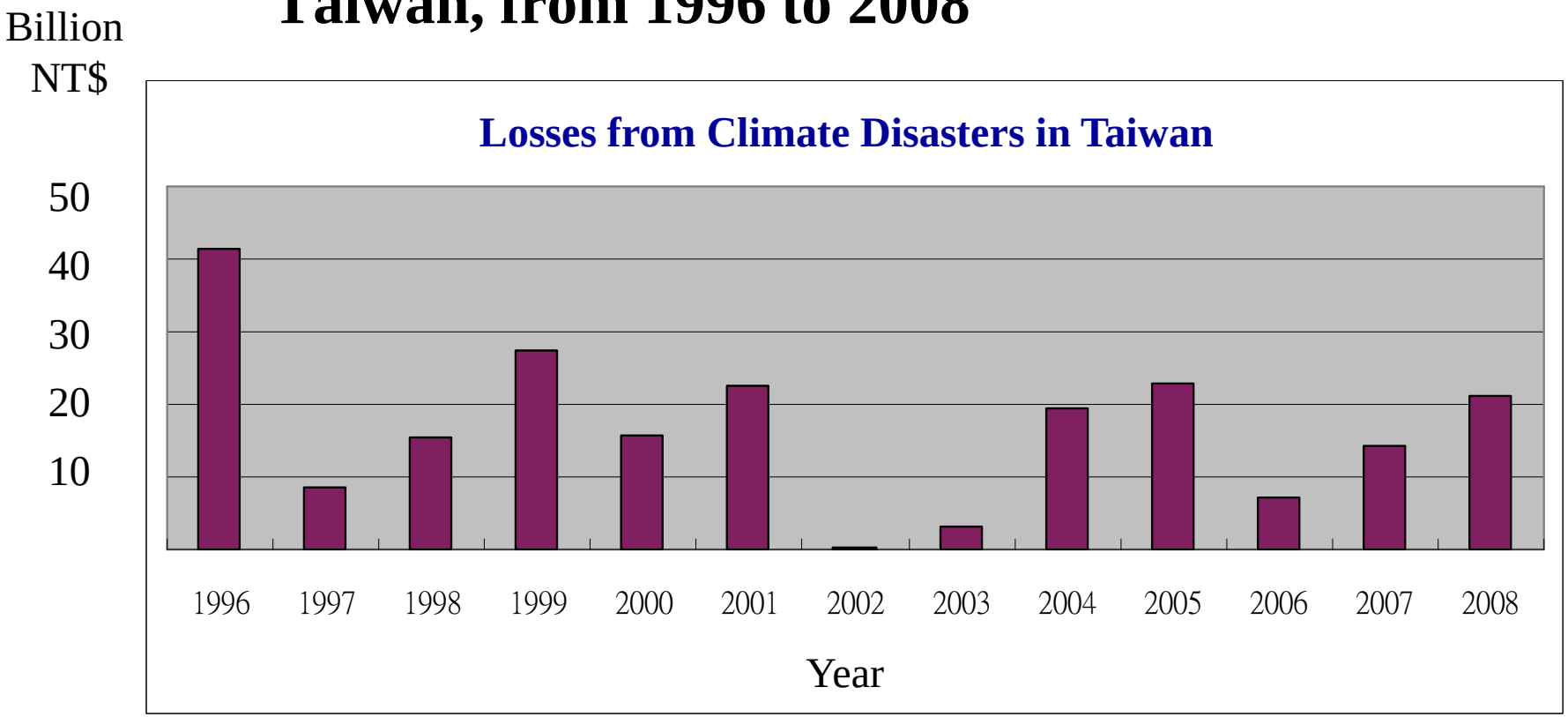
2. Short bar (-) indicates no estimation was made possibly because there is no model data or simply not significant enough.
3. SRES: Special Report on Emissions Scenarios published by IPCC in 2001. A2: High degree of population growth and primarily regional economic growth; B2: Economically, socially, and environmentally sustainable scenario.
4. Short-term:2010~2039；mid-term:2040~2069；long-term:2070~2099.

4. The Relationship Between the Impact and the Cost of Climate Change (7/11)

(4) Impacts of Climate Change on Taiwan's Economy

b. Historical Losses from Climate Disasters in Taiwan

- **Statistics of Losses from Climate Disasters in Taiwan, from 1996 to 2008**



4. The Relationship Between the Impact and the Cost of Climate Change (8/11)

(4) Impacts of Climate Change on Taiwan's Economy

c. Estimated Loss from Typhoon Morakot in 2009

a) **The estimated loss from Typhoon Morakot in 2009 was NT$90.5 billion (infrastructure damages, agriculture losses, flood damages to homes and manufactures are 65%, 22%, 9% and 2%, respectively).**

b) **Typhoon Morakot dropped Taiwan's third quarter real GDP in 2009 by NT$ 19-23 billion.**

c) **Taiwan's economic growth of the third quarter in 2009 fell by 0.6-0.7%.**

4. The Relationship Between the Impact and the Cost of Climate Change (9/11)

d. Historical Funding Approved by Taiwan's Central Government for Local Restorations in Major Disasters (Including Typhoons)

After the 921 Earthquake in 1999, funding approved by Central Government for local restorations in major disasters

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Number	1,319	11,410	106	144	5,294	5,311	2,205	3,558	6,820
$:100 million	27.7	225.9	0.9	1.3	110.3	75.0	50.7	60.5	132.6

Total Number：36,167；Total Amount：NT$ 68.49 billions

Xangsane	Toraji	Kammuri	Dujuan	Mindulle	June Flood	June Rainfall	June Storm	Kalmaegi
	Nari		Morakot	Aere	Haitang	Bilis	Wutip	Fung-wong
	Trami			Nock-ten	Matsa	Kaemi	Sepat	Sinlaku
					Talim	September Rainfall	Krosa	Jangmi
					Longwang			

*** Happens every year**

*** Average cost per restoration project is NT$1.89 million**

4. The Relationship Between the Impact and the Cost of Climate Change (10/11)

(5) Impacts of Climate Change Present An Unavoidable Challenge for Economy

- **The potential impacts from climate change can create immense turmoil in both the global and Taiwan's economies.**
- **Taiwan—with 0.34% of the world population and 1.7% of the global economic power—should gear up climate change response policies and measures.**
  - **The Total CO_2 emissions in Taiwan are 264.29 million tons in 2008, accounted for 0.90% of global emissions, and ranked 22nd in the world.**
  - **Taiwan's per capita CO_2 emissions are 11.53 tons (12.1 tons in 2007), ranked 17th in the world.**
  - **CO_2 intensity in Taiwan ranks 51st in the world.**

4. The Relationship Between the Impact and the Cost of Climate Change (11/11)

(5) Impacts of Climate Change Present An Unavoidable Challenge for Economy (Continued)

- **The benefits of a strong, early action on climate change, such as CO_2 emission reduction policies, can outweigh its costs considerably.**

5. Taiwan's Response to Climate Change (1/2)

- **Since President Ma Ying-Jeou took office in May 2008, building Taiwan into a low-carbon society has been a top priority.**
- **The Government announced the "Framework of Taiwan's Sustainable Energy Policy" in June 2008**
  - **Reducing nationwide CO_2 emissions to its 2008 level between 2016-2020, and to the 2000 level by 2025.**
  - **Developing aggressive carbon mitigation policies, such as improving energy efficiency by more than 2% per annum.**
- **The 3rd National Energy Conference was held in April 2009 in order to develop new guidelines on energy strategies.**

5. Taiwan's Response to Climate Change (2/2)

- The recently passed **"Statute for Renewable Energy Development"** sets 16% as the target for renewable energy by 2025.
- The revised **"Energy Management Act"** enhances energy efficiency standards.
- The Legislative Yuan **is reviewing the Greenhouse Gas Reduction Bill**, which adopts a three-step greenhouse gas emission controlling strategy.
- The Government has set up two task forces, the "Steering Committee on Energy Conservation and Carbon Reduction" and the "Steering Committee on New Energy Development and Promotion", to carry out its carbon policies.
- The Government is currently **drafting the "Framework of Taiwan's Climate Change Adaptation Policy"** .

6. Economic Impacts of Carbon Mitigation Policies (1/7)

(1) The Impacts of CO_2 Emission Reduction Policies on Taiwan's Economy

- In terms of reducing carbon dioxide emission, the effects of carbon tax or emission trading on the Taiwan's economy are generally considered as negative.
- The negative impact of carbon tax **can be reduced by adopting a progressive approach instead of an one-step approach.**
- The negative impact of carbon tax may **be offset further by industry linkage effects of energy-saving investments and supplementary tax cuts.**

6. Economic Impacts of Carbon Mitigation Policies (2/7)

(1) The Impacts of CO_2 Emission Reduction Policies on Taiwan's Economy (continued)

- According to Dr. Liang's analysis
  - **Strategy 1 : Carbon tax approach without tax cut + Industry linkage effects of energy-saving investments.** The economic growth rate of this strategy will be **positive**.
  - **Strategy 2 : Carbon tax approach with tax cut + Industry linkage effects of energy-saving investments.** The economic growth rate of this strategy will also be **positive**.

6. Economic Impacts of Carbon Mitigation Policies (3/7)

(2) The Impacts of CO_2 Emission Reduction Policies on Taiwan's Economy (Strategy 1)

a. The Analysis from the Academia Sinica, Taiwan (Dr. Liang, Chi-Yuan, 2006)

a) This analysis ignored industry linkage effects of energy-saving investments

b) Assumptions:

- Carbon tax (without tax cut) as the instrument for Taiwan to reach its CO_2 reduction target.
- Taiwan's CO_2 reduction target: 25% by 2020.
- Either adopting the one-step tax-based approach or the progressive tax-based approach.

6. Economic Impacts of Carbon Mitigation Policies (4/7)

(2)

a. (Continued)

c) Analysis Results for the Impacts in 2020:

- **One-Step Approach:** -1.57% on economic growth rate; NTD$1,734/tonne for CO_2 marginal abatement cost.
- **Progressive Approach:** -1.19% on economic growth rate; NTD$1,186/tonne for CO_2 marginal abatement cost.

The Taiwan's Economic Impacts of 25% of CO_2 Emission Reduction with Different Carbon Tax Approaches (without Tax Cut and Regardless of Industrial Linkage Effects of Energy-saving Investments) in 2020

	One-step Approach	**Progressive Approach**
CO_2 Emission Reduction (%)	**-25.77**	**-25.31**
Price Change (%)	**2.26**	**1.01**
Economic Growth (%)	**-1.57**	**-1.19**
Annual Average Abatement Cost in 1999 Price (NT$/tonne)	**1,734**	**1,186**

6. Economic Impacts of Carbon Mitigation Policies (5/7)

(2) (Continued)

b. The Analysis from the Academia Sinica, Taiwan (Dr. Liang, Chi-Yuan, 2010)

a) This analysis considered the industry linkage effects of the energy-saving investments, which can offset the impacts of CO_2 mitigation policies on economy.

- Reducing energy import in Taiwan has less impact on the energy industries than most countries because Taiwan imports 99% of its energy.
- Reducing energy import can increase the GDP.
- Energy-saving investments promote the development of the energy-saving industries.
- The jobs created by the energy-saving investments are usually 3-4 times of those created by investments on electricity generation.

b) Assumptions:

- The same as those for the analysis of the Strategy 1
- Considering the industry linkage effects of the energy-saving investments because of additional regulation— improving energy efficiency by 2% per annum

6. Economic Impacts of Carbon Mitigation Policies (6/7)

(2)

b. (Continued)

c) Analysis Results for the Impacts in 2020

Number	Item	Economic Growth (%)	Jobs (Ten Thousands)
(1)	Effects from 25% of Energy Saving （Carbon Tax without Tax Cut and Regardless of Industry Linkage Effects of Energy-Saving Investments ）	-1.19%	-24.7
(2)	Industry Linkage Effects of Energy-Saving Investments	+1.64%	+34.0
(3) =(1)+(2)	Net Effects	+0.45%	+9.3

Note: (1) Carbon tax with progressive approach;

6. Economic Impacts of Carbon Mitigation Policies (7/7)

(3) The Impacts of CO2 Emission Reduction Policies on Taiwan's Economy (Strategy 2)

- **The Analysis from the Academia Sinica, Taiwan (Dr. Liang, Chi-Yuan, 2010)**

a. Assumptions:

- The same as those for the analysis of the strategy 1
- Considering the effects of supplementary tax cut

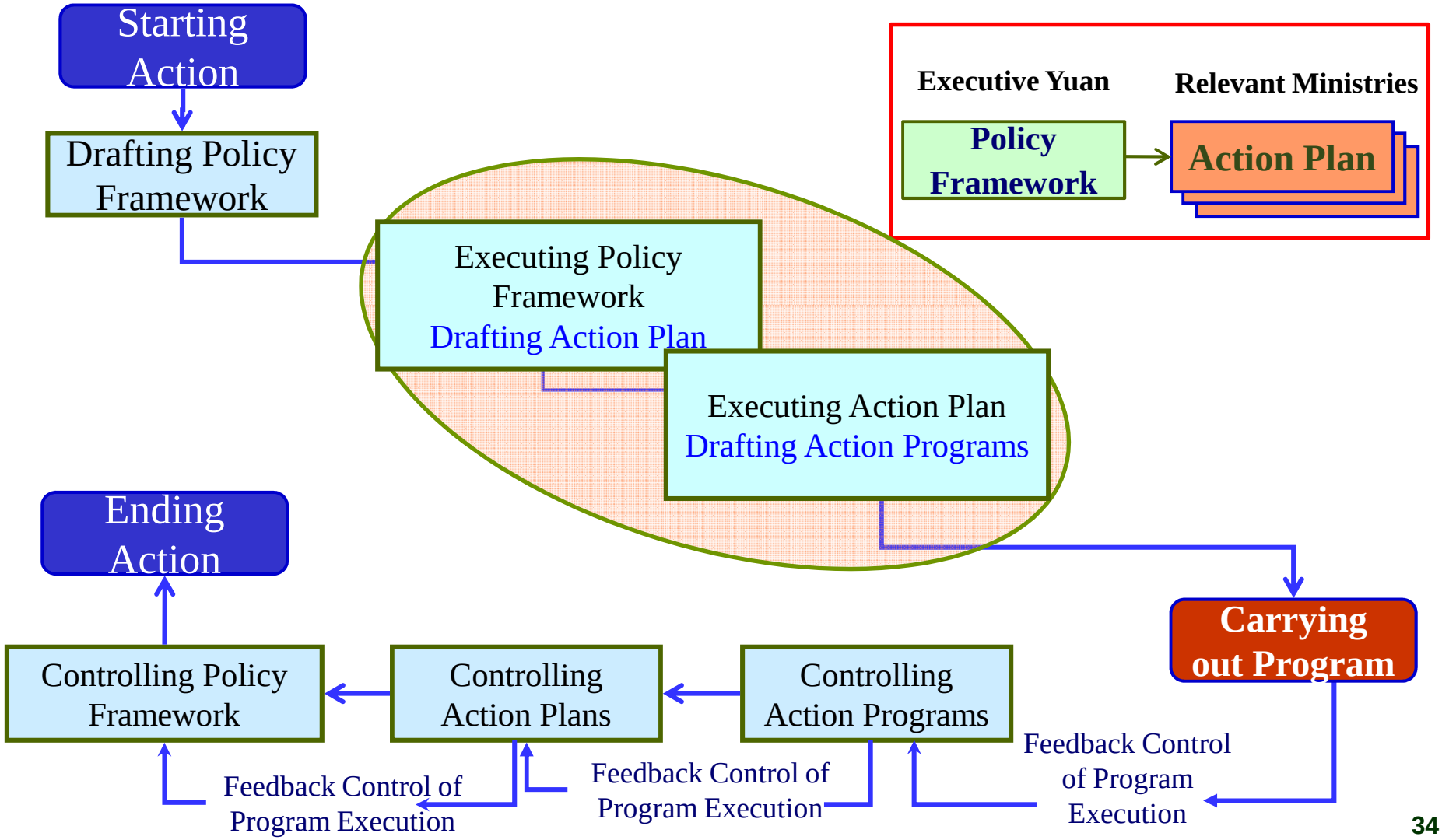
b. Analysis Results for the Impacts in 2020

Number	Item	Economic Growth (%)	Jobs (Ten Thousands)
(1)	Effects from 25% of Energy Saving (Carbon Tax with Supplementary Tax Cut and Regardless of Industry Linkage Effects of Energy-Saving Investments)	-0.59%	-12.2
(2)	Industry Linkage Effects of Energy-Saving Investments	+1.64%	+34.0
(3) =(1)+(2)	Net Effects	+1.05%	+21.8

Note: (1) Carbon tax with progressive approach;

7. Taiwan's Climate Adaptation Policies (1/3)

(1) The Structure for Taiwan's Adaptation Policies



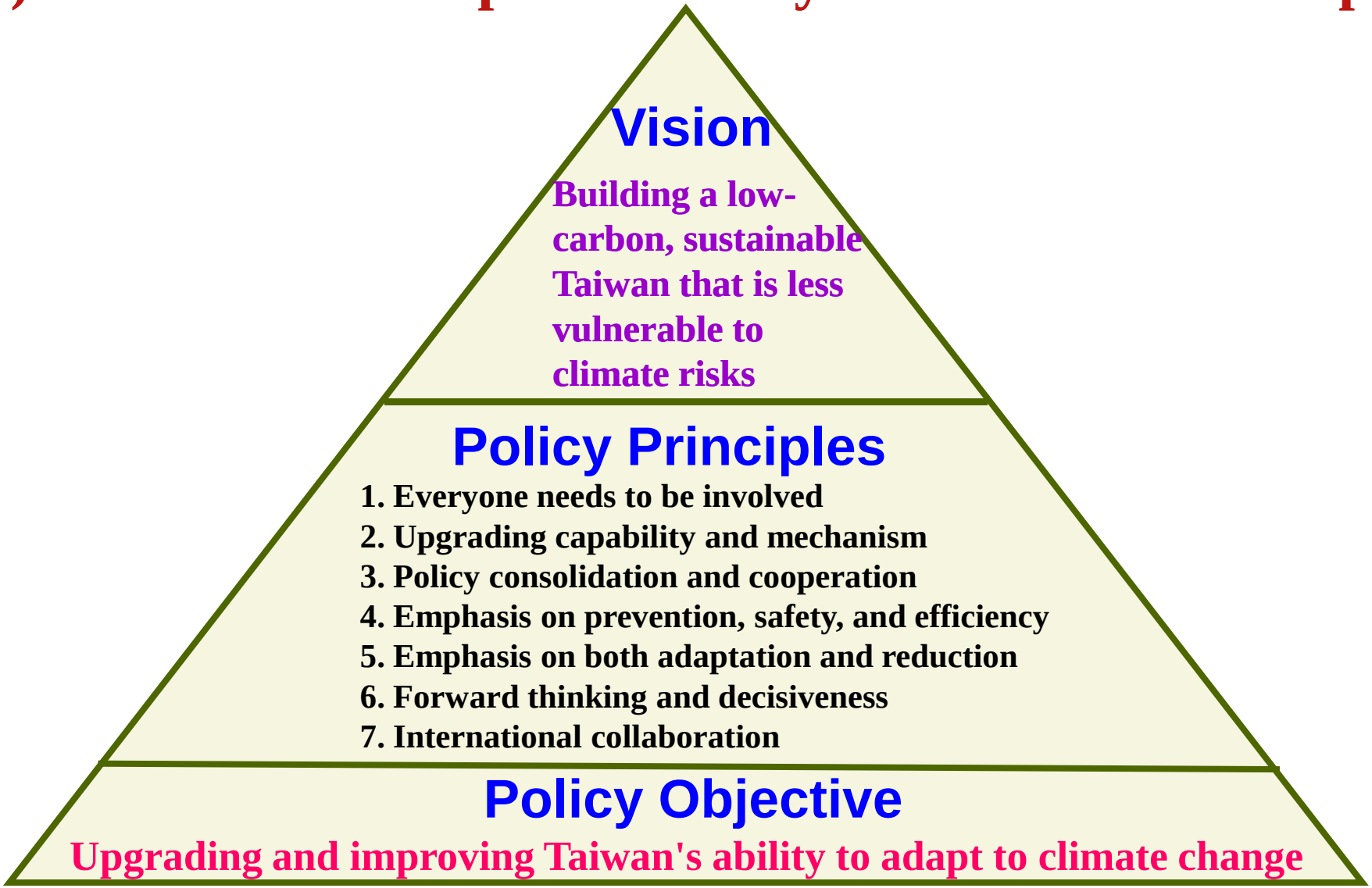
7. Taiwan's Climate Adaptation Policies (2/3)

(2) Taiwan's Climate Change Adaptation Policy Framework and Action Plan

- **CEPD is scheduled to complete Taiwan's Climate Change Adaptation Policy Framework and consolidate/complete the National Adaptation Programs of Action this year (2010)** so they can serve as the basis for related future government works.
  1. Inviting involved ministries, experts, academicians, NGOs, and representatives from the industries to form a task force to plan and push for climate change adaptation policy framework and its action program. (2010.1.29)
  2. Collecting and consolidating current relevant adaptation policies, researches, action plans, and programs; also considering international experiences when drafting Taiwan's climate change adaptation policy framework.
  3. Assisting ministries to draft adaptation action programs.
  4. Consolidating those adaptation programs to draft a national adaptation program.

7. Taiwan's Climate Adaptation Policies (3/3)

(3) Vision of the Adaptation Policy and the Basic Principle



8. Conclusion (1/2)

1. **Because of its geographic and geological factors, Taiwan suffers from frequent earthquakes and typhoons. Potential hazard areas (including debris flow and flood) are all over the island. Extreme weather will further aggravate the frequency and intensity of these disasters. The impact on the economy must not be overlooked. Therefore, pushing for policies that can slow down and adapt to the climate change has become a very urgent issue.**
2. **The costs of active climate policies may slow the economic growth, but these active CO_2 mitigation policies also create jobs, incomes, and the development of new technologies, while reducing the negative impact of extreme climate.**

8. Conclusion (2/2)

3. **Recognizing that the transition to a low-carbon economy will not only challenge Taiwan's competitiveness but also bring forth opportunities for growth, building Taiwan into a low-carbon society is one of President Ma's priority policies.**
4. **The Government has announced that Taiwan will reduce nationwide CO_2 emissions to its 2008 level between 2016-2020, and to the 2000 level by 2025.**
5. **Because of the uncertainties in climate change and its extreme climatic events, we should continue the research on climate change's impacts, the appropriate responses and the analysis on cost-effectiveness as the basis for government policies.**

Thank You