

# **The Economics of Climate Change in East Asia**

**- Japan Presentation -**

**Tokyo, 23 October 2013**

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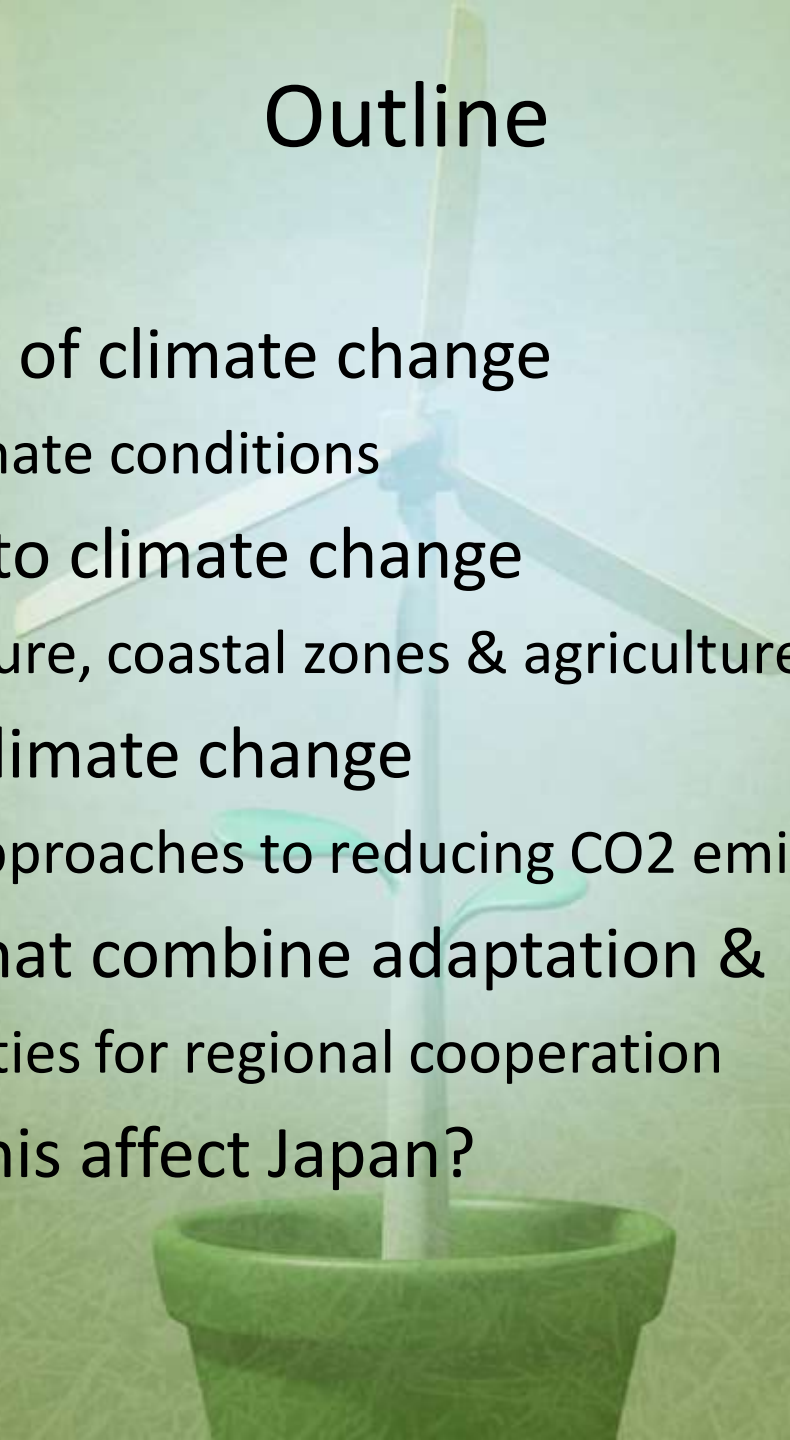
**Gordon Hughes, University of Edinburgh**

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# Outline

- The Project
- The impacts of climate change
  - Future climate conditions
- Adaptation to climate change
  - Infrastructure, coastal zones & agriculture
- Mitigating climate change
  - Efficient approaches to reducing CO2 emissions
- Strategies that combine adaptation & mitigation
  - Opportunities for regional cooperation
- How does this affect Japan?



# **Part 1**

## **The Project**



# The First Regional Climate Change Study for East Asia

- Part of a series of ADB projects on the “Economics of Climate Change”
- Objectives
  - (i) Help prioritize adaptation and mitigation in the region
  - (ii) Better understanding of financing needs for adaptation and mitigation in the region
  - (iii) Identify possible areas of regional cooperation, e.g. mitigation and carbon trading, technology transfer, adaptation practices




# Close cooperation with institutions in partnering countries

- Domestic workshops on climate change impact and low carbon growth strategies
- Regional workshops to share respective domestic findings and to foster regional cooperation
- Presentation of preliminary findings at COP-17 (Durban, South Africa, 6 December 2011)



# Participating Institutions



## *Japan*

- National Institute for Environmental Studies (NIES)
- Institute for Global Environmental Strategies (IGES)
- Mizuho Information and Research Institute

## *Republic of Korea*

- Global Green Growth Institute
- Seoul National University

## *People's Republic of China*

- National Development and Reform Commission (NDRC)
- Tsinghua University

Korea International Cooperation Agency  
(co-funder of the project) together with  
the ADB

## *Mongolia*

- Clean Development Mechanism Center
- Institute of Meteorology and Hydrology
- University of Science and Technology of Mongolia

## *Other Participating Institutions*

- Massachusetts Institute of Technology, USA
- University of Colorado at Boulder, USA
- University of Edinburgh, UK
- University of Southampton, UK
- International Institute for Applied Systems Analysis, Austria
- Basque Centre for Climate Change, Spain

## **Part 2**

# **The impacts of climate change**



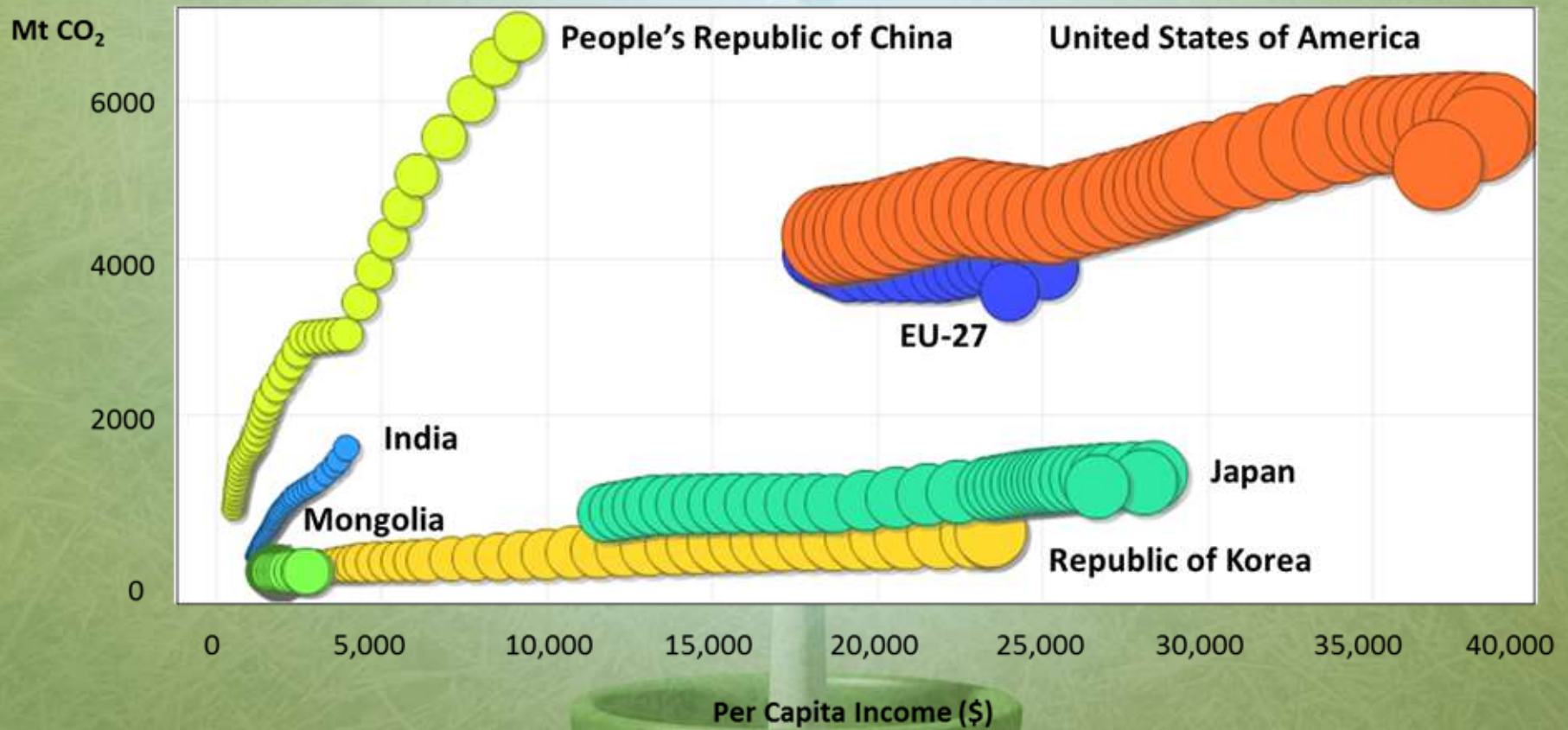
# Context

A green seedling with two leaves growing out of a green pot, with a white wind turbine in the background.

- East Asia is critically important to global mitigation efforts.
- The region has made great strides in reducing the energy intensity of its economies
- However, per capita emissions have been increasing in the region.
- The region is also quite vulnerable to some impacts of climate change, particularly those associated with sea-level rise, cyclones, and flooding.
- Countries in East Asia are exposed to a variety of climate-related natural disasters because of their size and location.
- Climate models project a warmer and wetter East Asia.



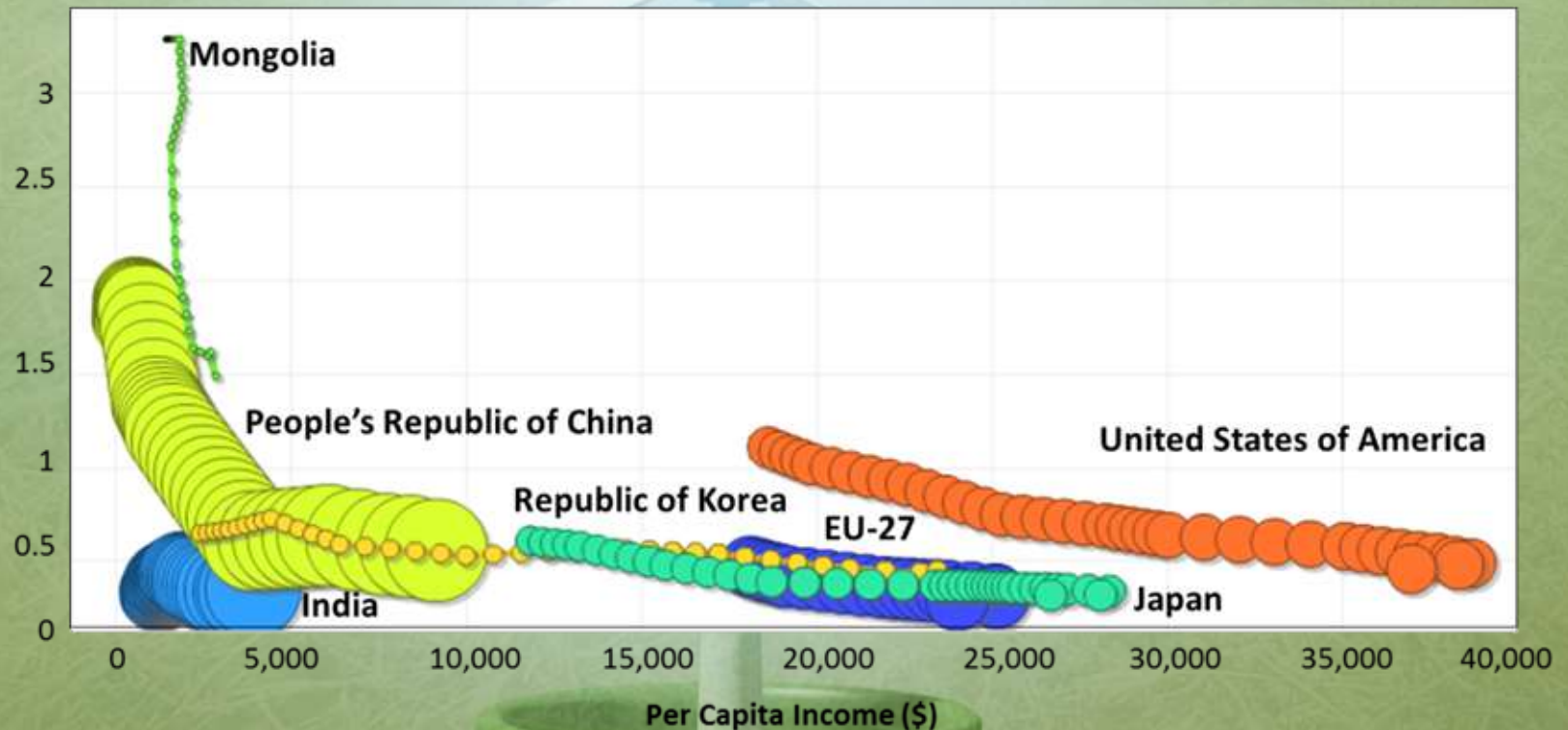
**CO2 emissions have increased as countries get richer. In particular, the PRC's emissions have increased to about 7 times their level in 1971**



***CO2 emissions vs GDP per person, 1971-2009***

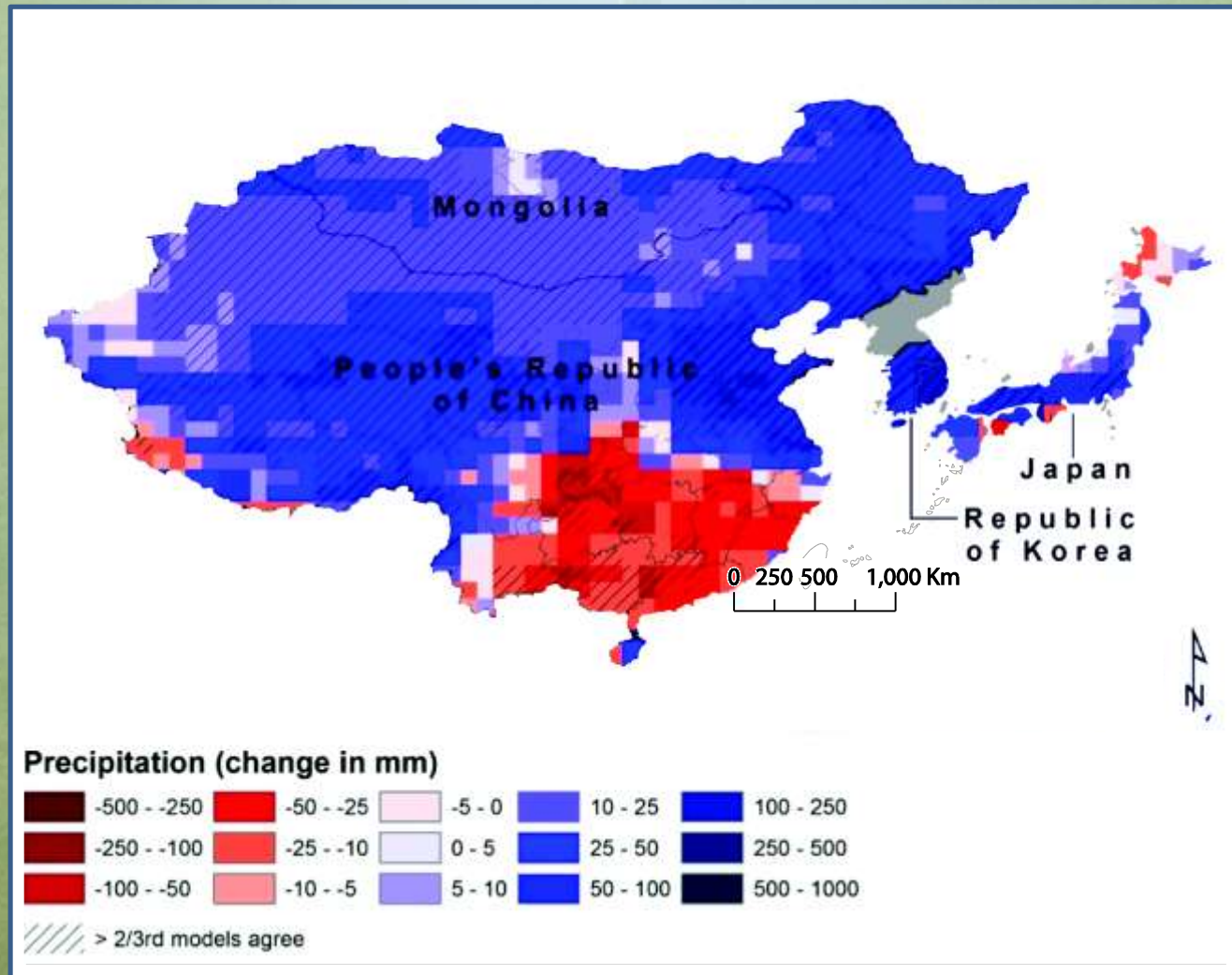
**But, emissions of CO<sub>2</sub> per \$ of GDP have fallen steadily in most countries but especially in the PRC**

kg of CO<sub>2</sub> per Unit of GDP



CO<sub>2</sub>-intensity vs GDP per person, 1971-2009

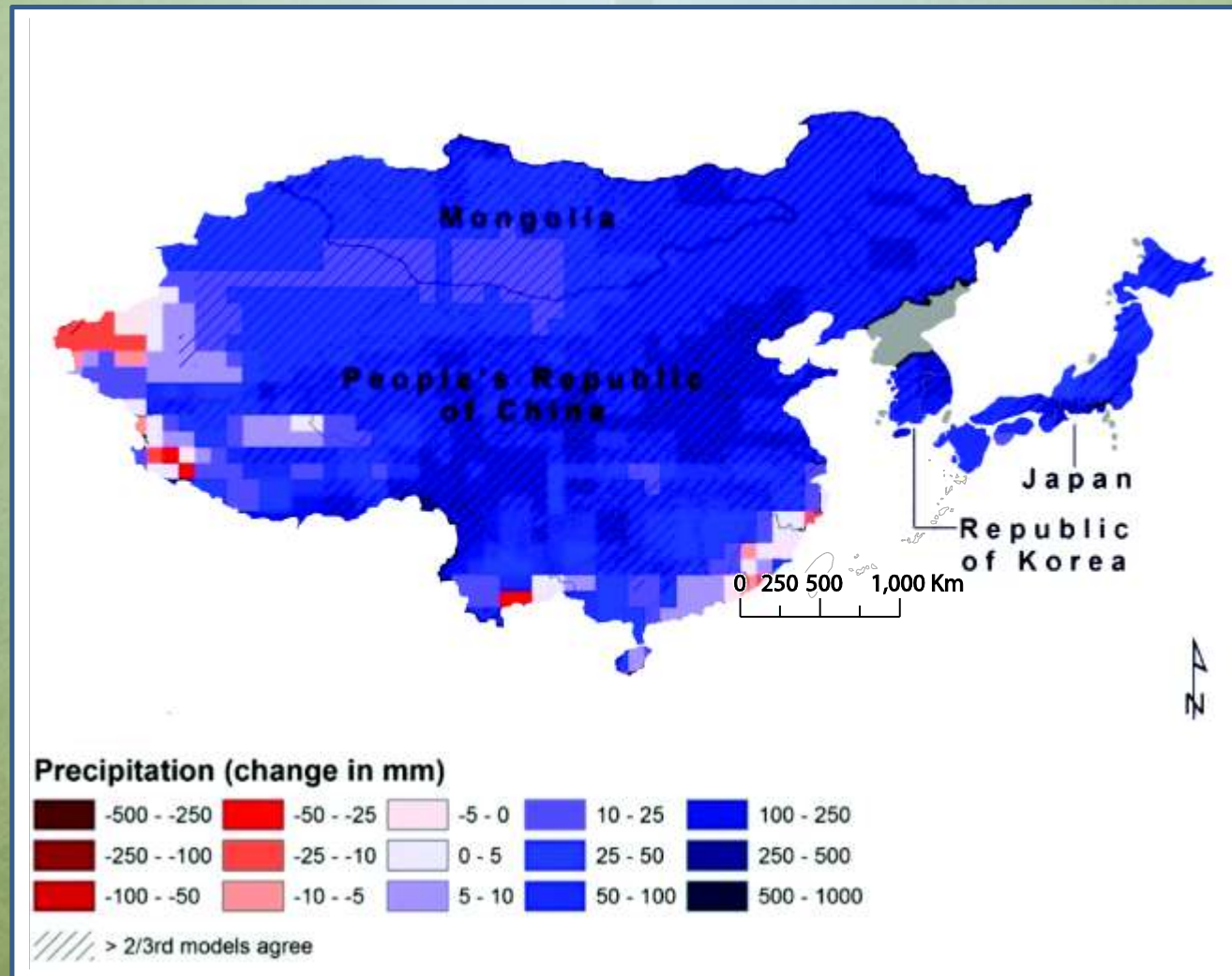
Annual precipitation is expected to increase by 2050 over most of East Asia with the exception of South-East China



*Changes in mean annual precipitation 2050*



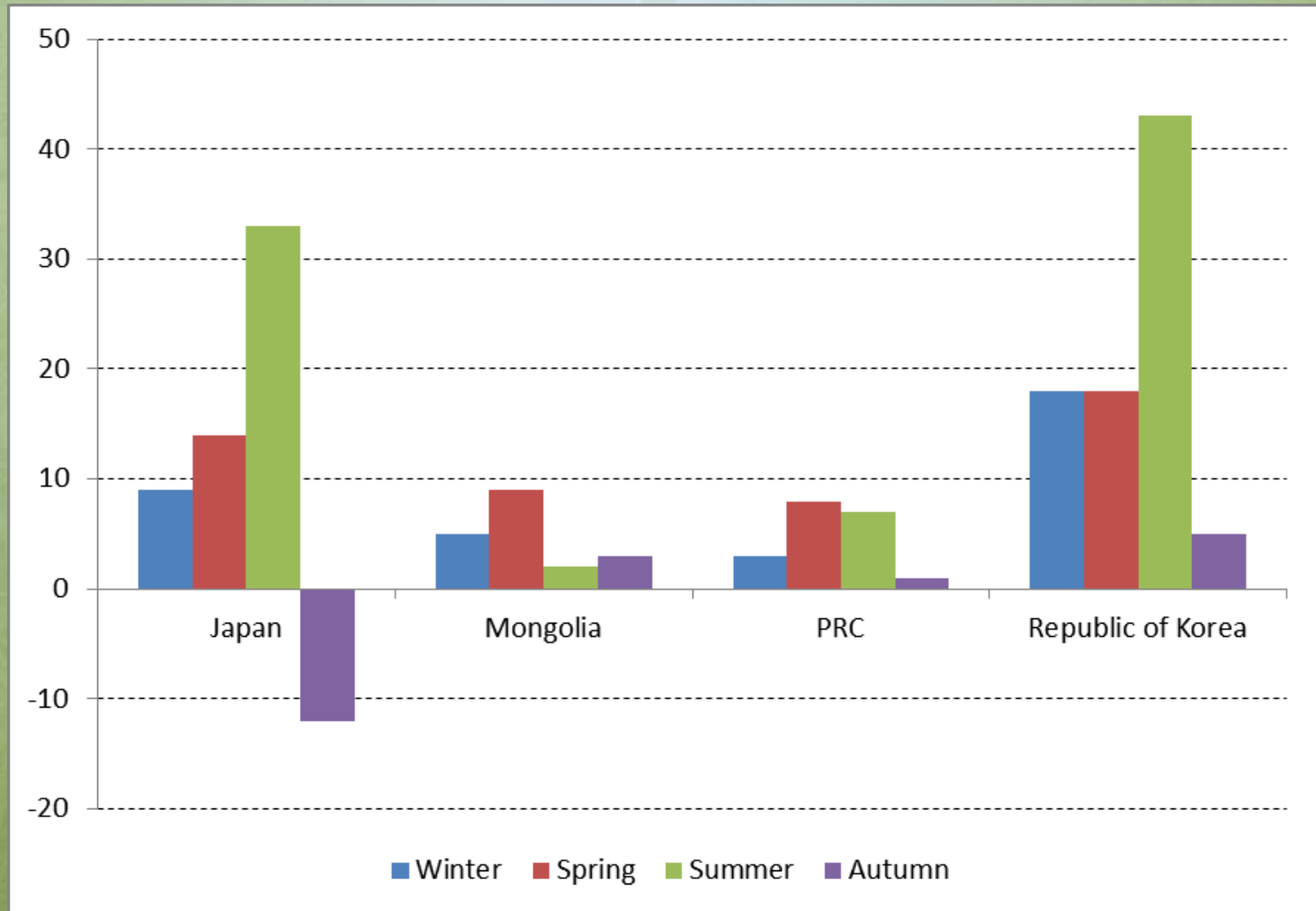
By 2090 annual precipitation is expected to increase in almost all regions of East Asia



*Changes in mean annual precipitation 2090*

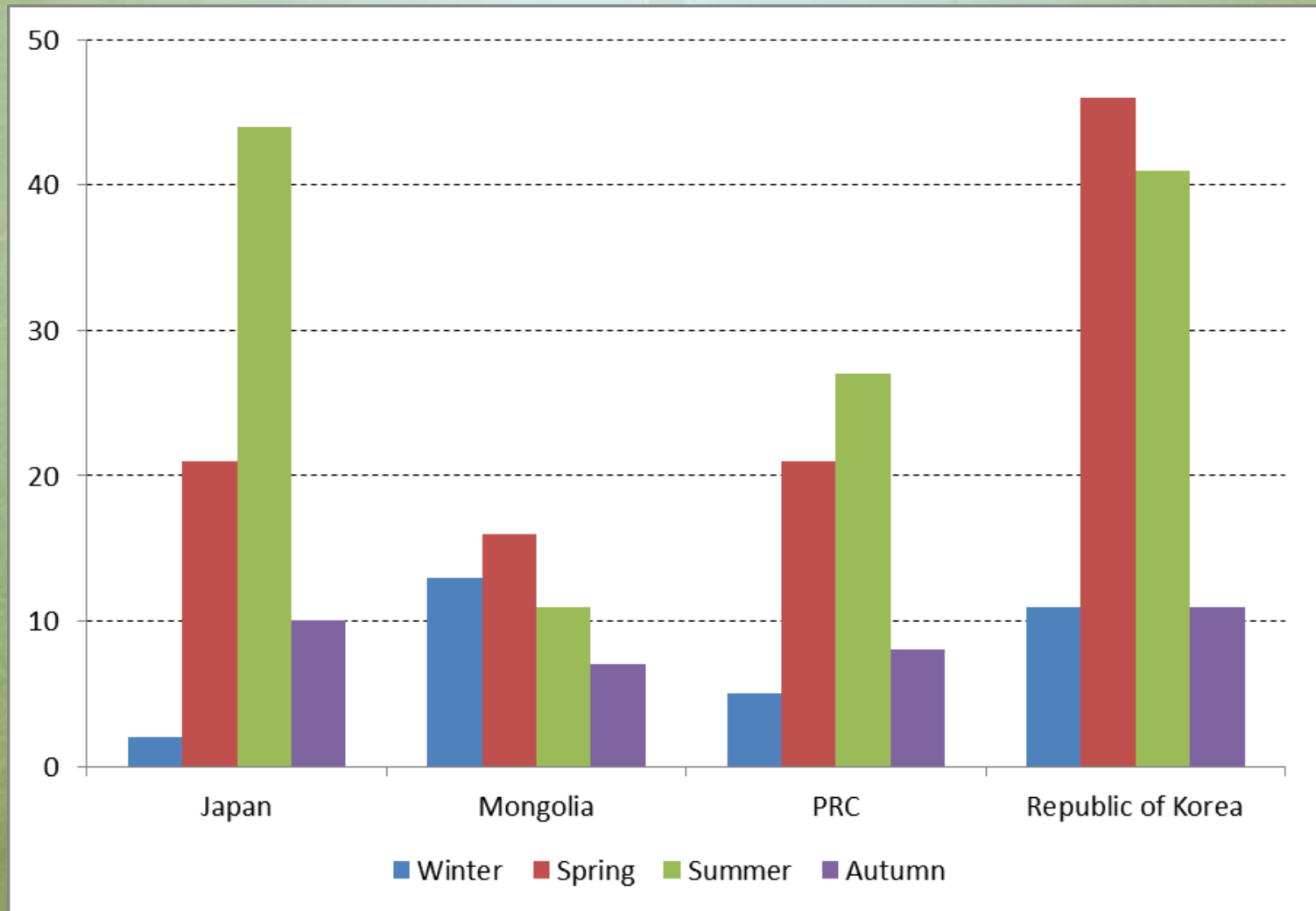


**The increase in rainfall 2050 will be concentrated in spring & summer – especially in Japan and Korea**



***Changes in seasonal precipitation 2050***

**The pattern of 2050 is reinforced by 2090 with significant increases in precipitation in the spring and summer months**



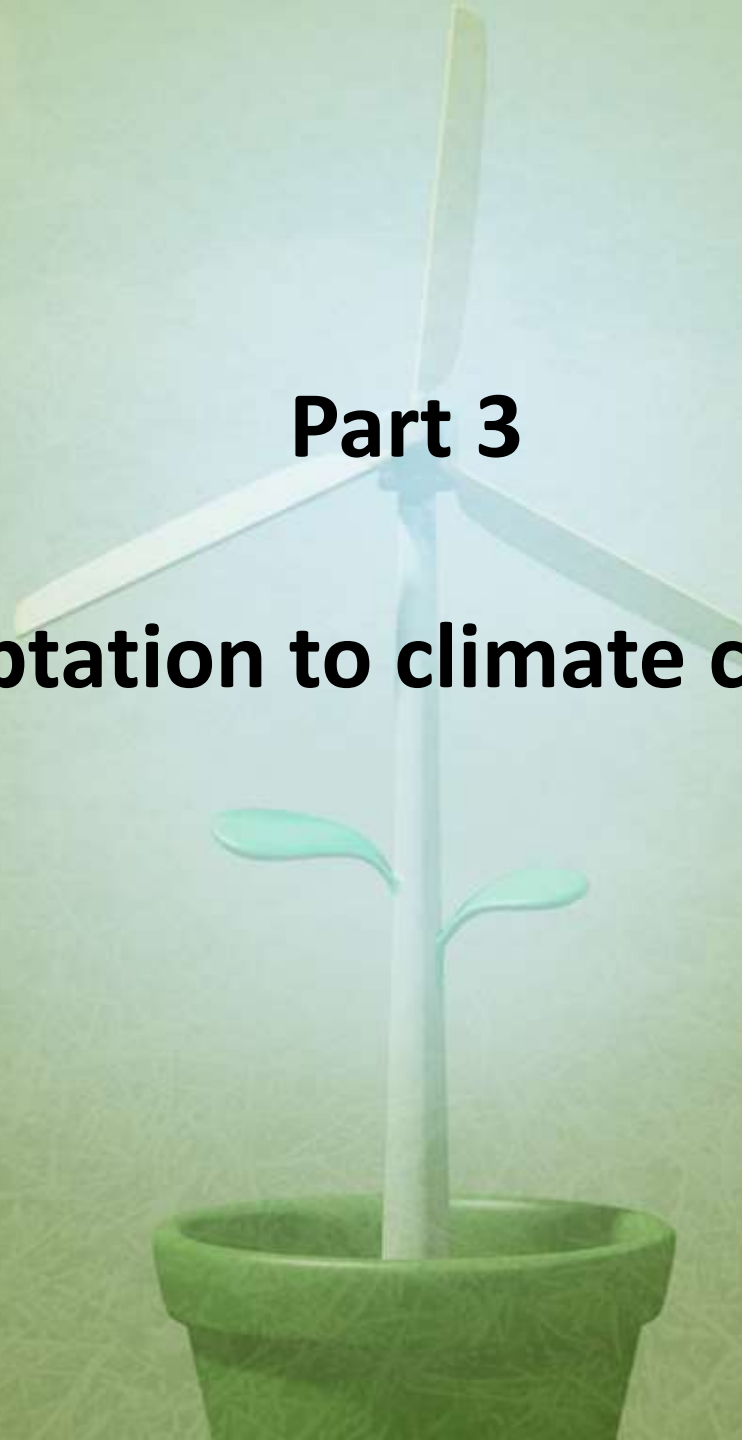
***Changes in seasonal precipitation 2090***

# Defining terms: adaptation and mitigation

- Adaptation covers all actions designed to reduce the impact of climate change that is occurring
  - Planned (ex-ante) adaptation covers investments made in anticipation of climate change
  - Responsive adaptation involves higher spending on maintaining or upgrading assets as they are affected
  - Planned adaptation may be cheaper but the expenditures are earlier and may be based on incorrect assumptions
- Mitigation covers all actions designed to reduce emissions of greenhouse gases

## **Part 3**

# **Adaptation to climate change**

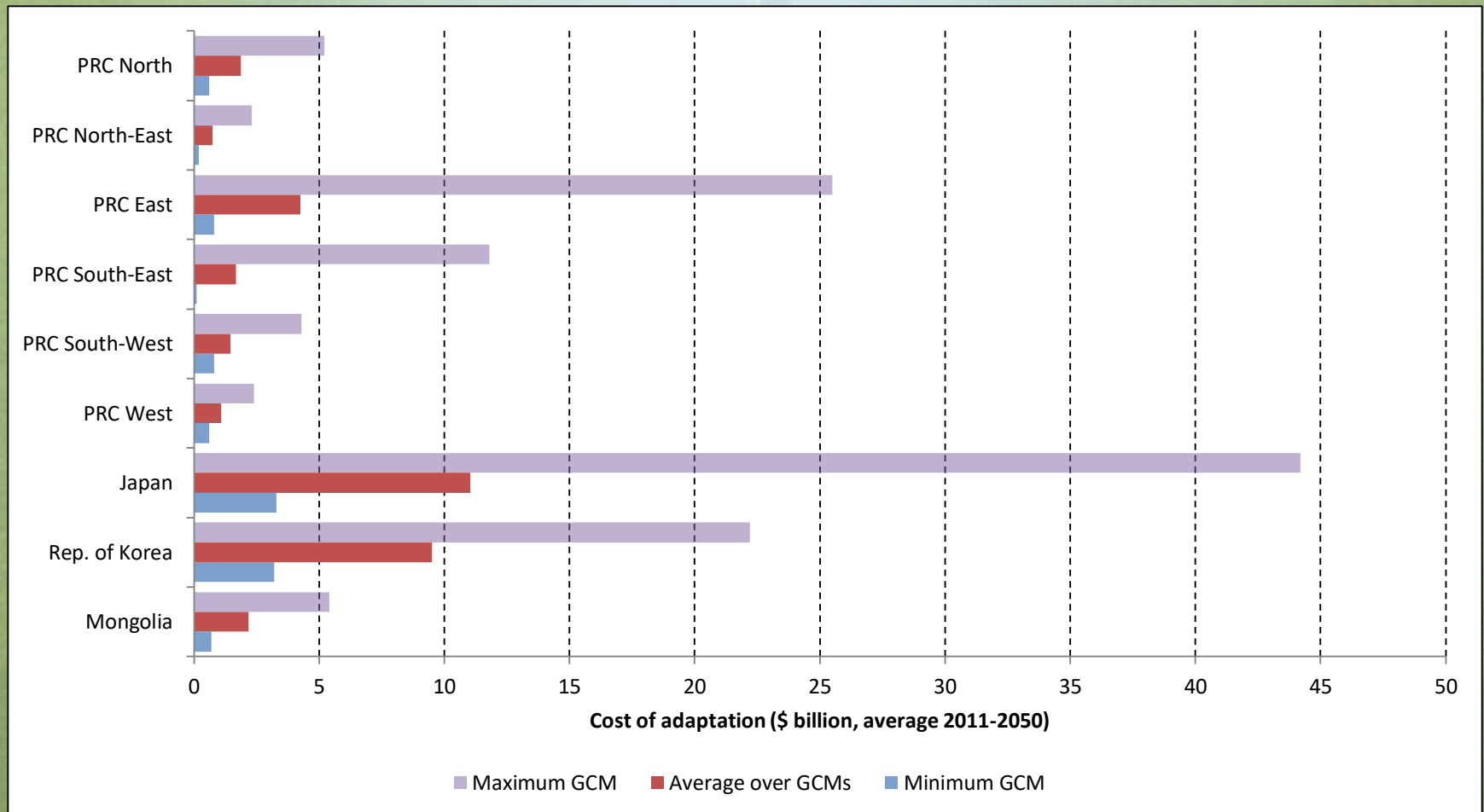




# Adaptation in the infrastructure sector

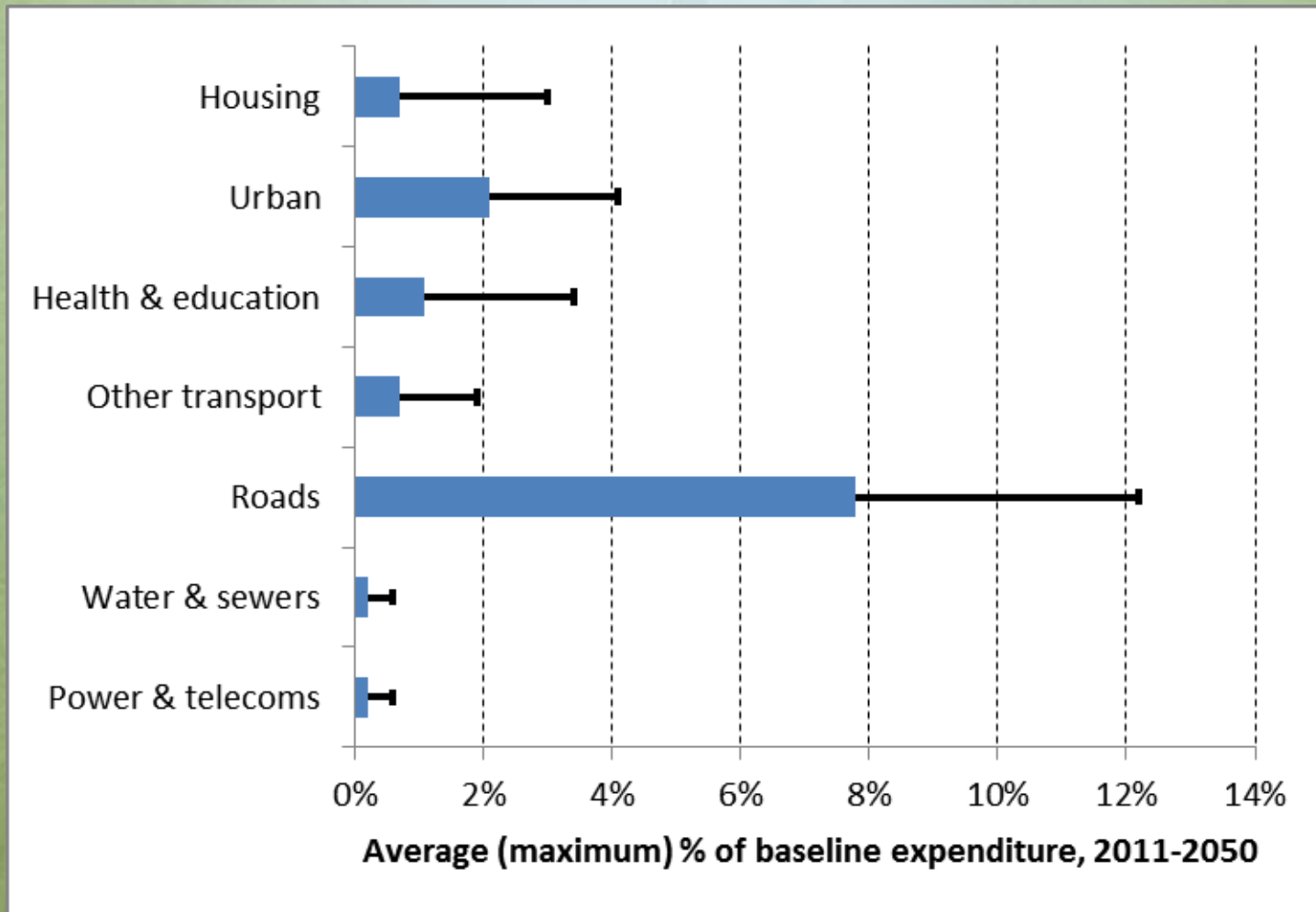
- Costs of adaptation, expressed as a proportion of baseline expenditures, are small in East Asia.
- Mongolia is the country most affected by the variability of adaptation costs.
- Roads have the highest relative costs of climate proofing.
- Even under perfect foresight:
  - Japan and the Republic of Korea should climate proof all infrastructure built from now on.
  - For the PRC, the net benefits of ex-ante adaptation for infrastructure are negative except for roads.

# The costs of adaptation vary greatly across climate scenarios, particularly in the PRC East region, Japan and Korea



***Costs of adaptation for infrastructure by region/country (\$ billion per year, 2011-2050)***

**The cost of adaptation is heaviest for roads – 8% of baseline spending on average and up to 12% for the worst scenario**



***Costs of adaptation for East Asia by sector (% of baseline expenditures, 2011-2050)***

# Coping with extreme weather events

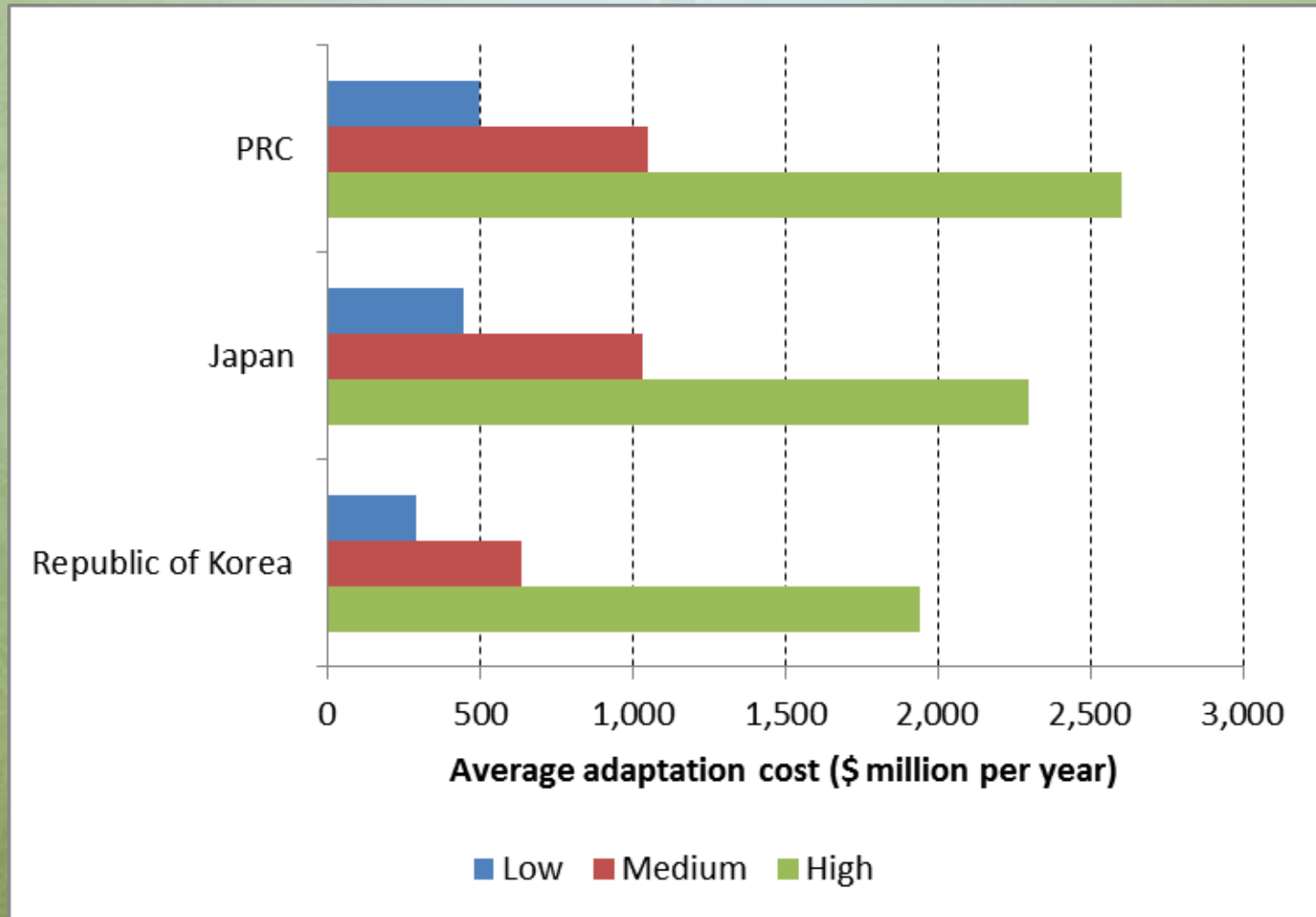
- The increase in economic losses due to cyclones may be significant in Japan and the Republic of Korea, but the costs of adaptation are modest.
- The level of protection against cyclones in the PRC seems to be too low.
- The increase in average losses caused by short-term flooding due to climate change in the PRC by 2050 is modest, but there are large variations across climate scenarios.
- The risks associated with cumulative flooding in the PRC, especially in the Yangtze River basin, may increase substantially under a small number of climate scenarios.



# Coastal adaptation

- Coastal adaptation, including beach nourishment and the construction of sea dikes, can reduce the economic losses due to sea-level rise by 99%.
- Adaptation costs are dominated by the capital costs of building sea dikes, though the cost of maintaining sea dikes increases over time.
- The cost of upgrading ports in East Asia is about \$400 million per year under the medium scenario with 77% required for ports in the PRC.
- The incremental cost of adapting to climate change in East Asia is \$2.7 billion per year for 2010-2050 under the medium scenario with a range from \$1.2 billion to \$6.8 billion per year over all of the scenarios examined.
- Coastal adaptation to climate change is highly cost effective.

**The cost of coastal adaptation is \$0.5-1.0 billion per year for each country in the medium scenario and 2-3 times that in the worst scenario**

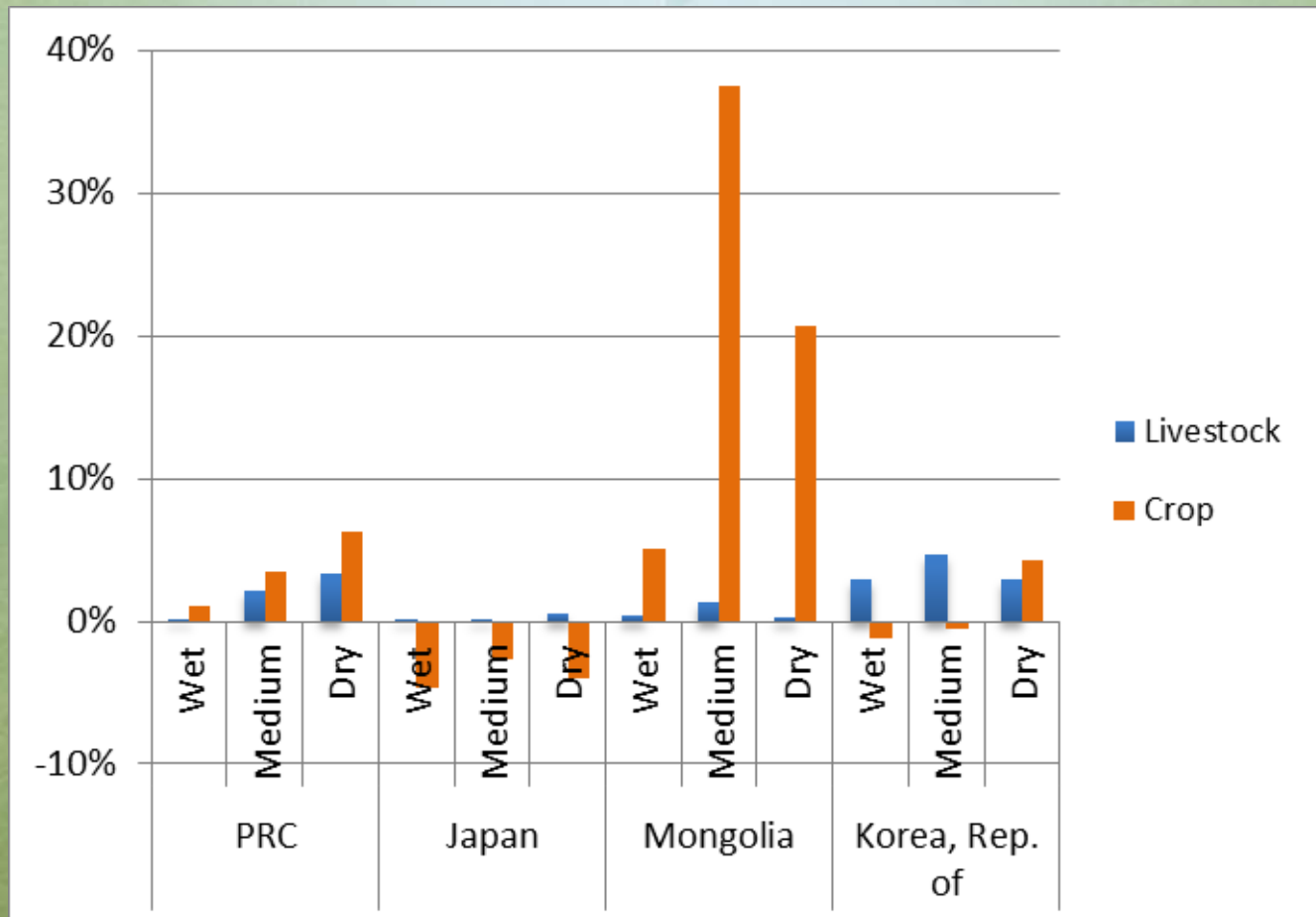


***Average cost of coastal adaptation by sea level rise scenario (\$ million per year, 2011-2050)***

# Climate change and agriculture

- Allowing for climate impacts on yields, production & trade
  - crop production will increase in 2050 in Japan, the Republic of Korea, and Mongolia.
  - crop production will decrease by 1%–4% in the PRC in 2050.
- Calorie consumption in 2050 will be lower in the PRC and, especially, Mongolia under the worst climate scenario.
- Adaptation takes the form of a consumer subsidy designed to restore the average level of calorie consumption.
  - The cost of adaptation in 2050 for East Asia varies from \$10 billion to \$33 billion depending upon the growth in yields.
  - Adaptation via a consumer subsidy will benefit farmers in the PRC.

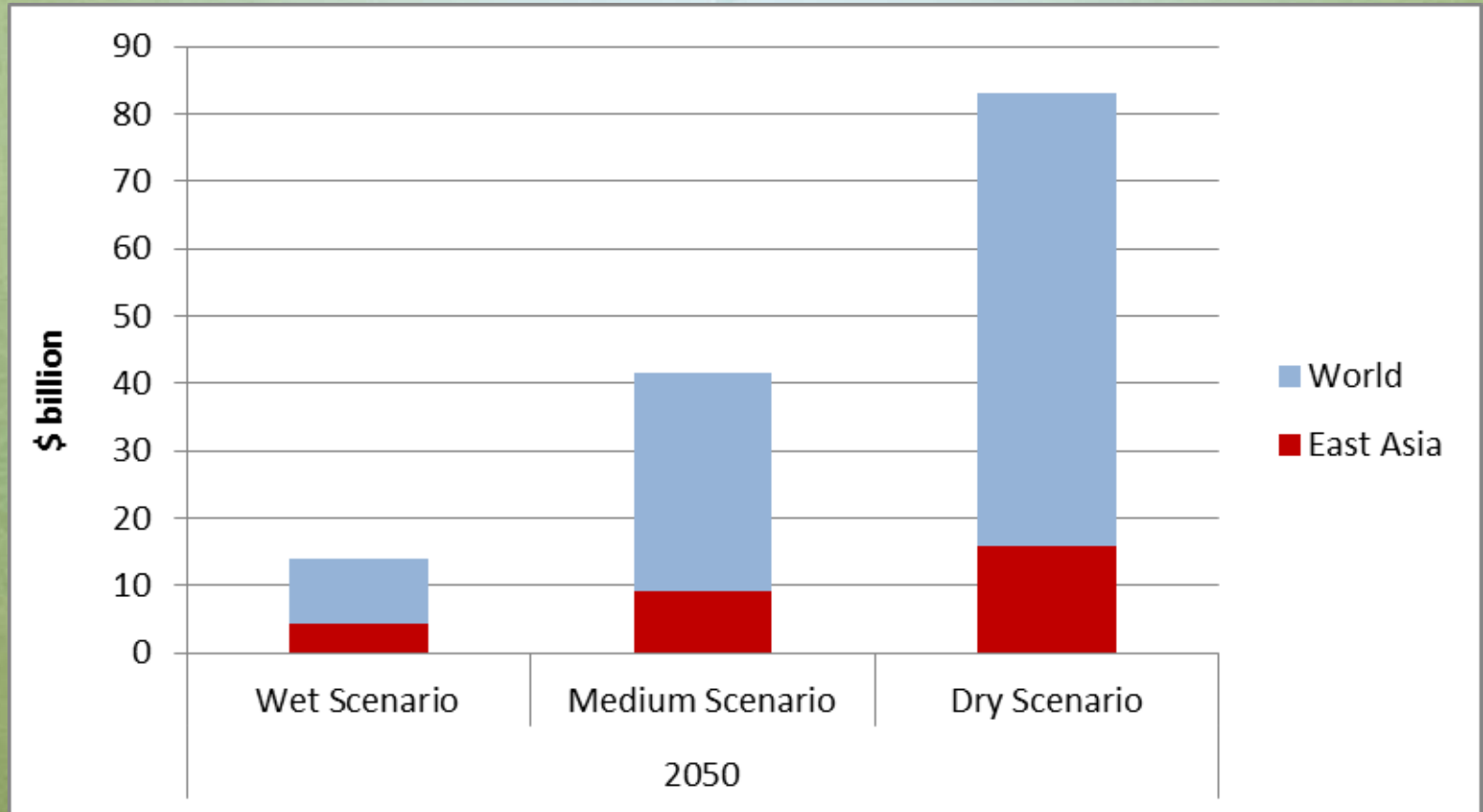
## The impacts of climate change on agricultural prices in 2050 will be small with the exception of crops in Mongolia



*Impact of climate change on agricultural prices in East Asia in 2050*

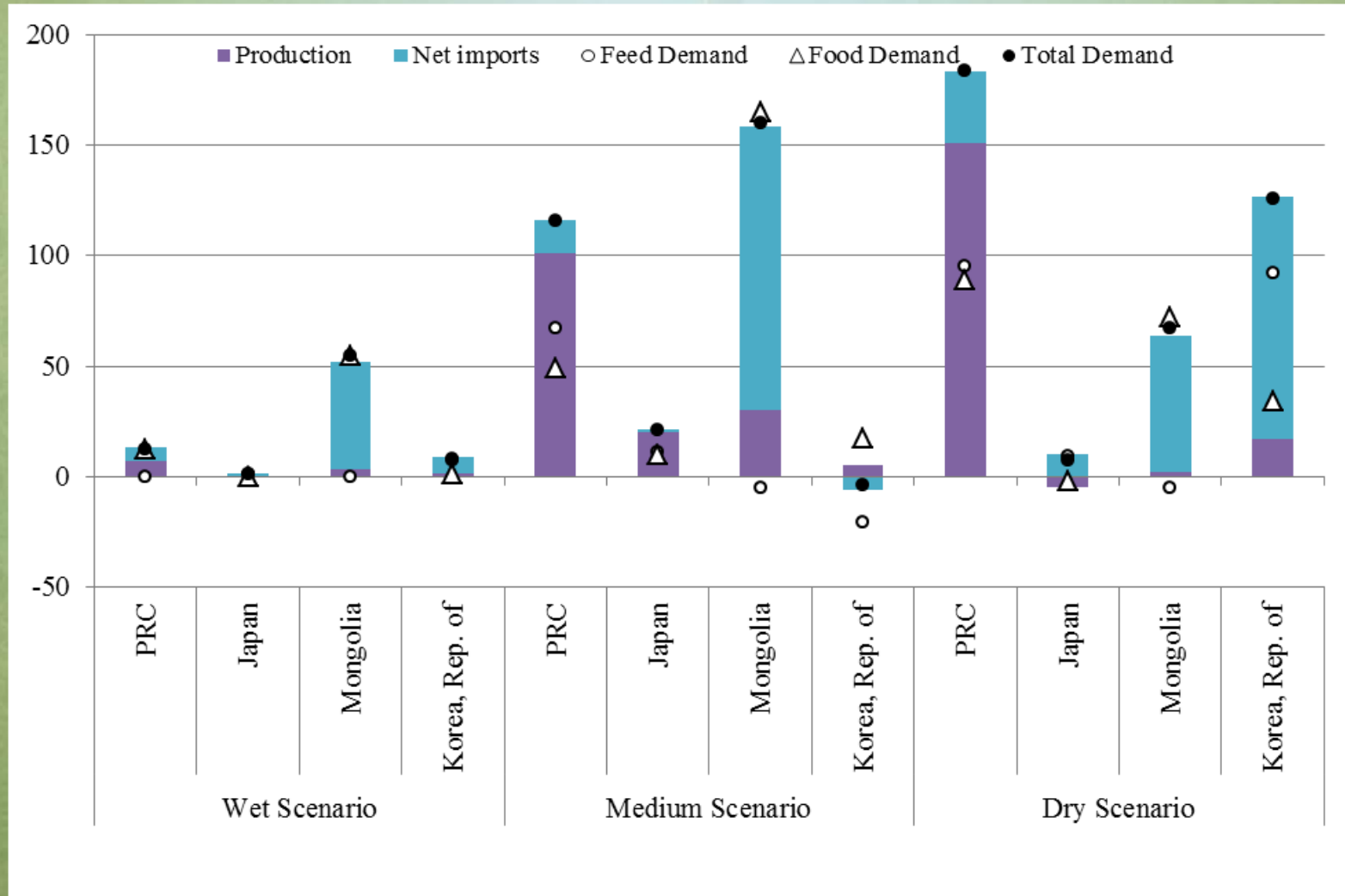


**The costs of agricultural adaptation, via a consumer subsidy, may be \$5 - \$15 billion in 2050**



***Cost of adaptation to climate change for agriculture via a consumer subsidy, 2050***

# Mongolia will rely on imported food in adapting to climate change, whereas crop production will increase in China

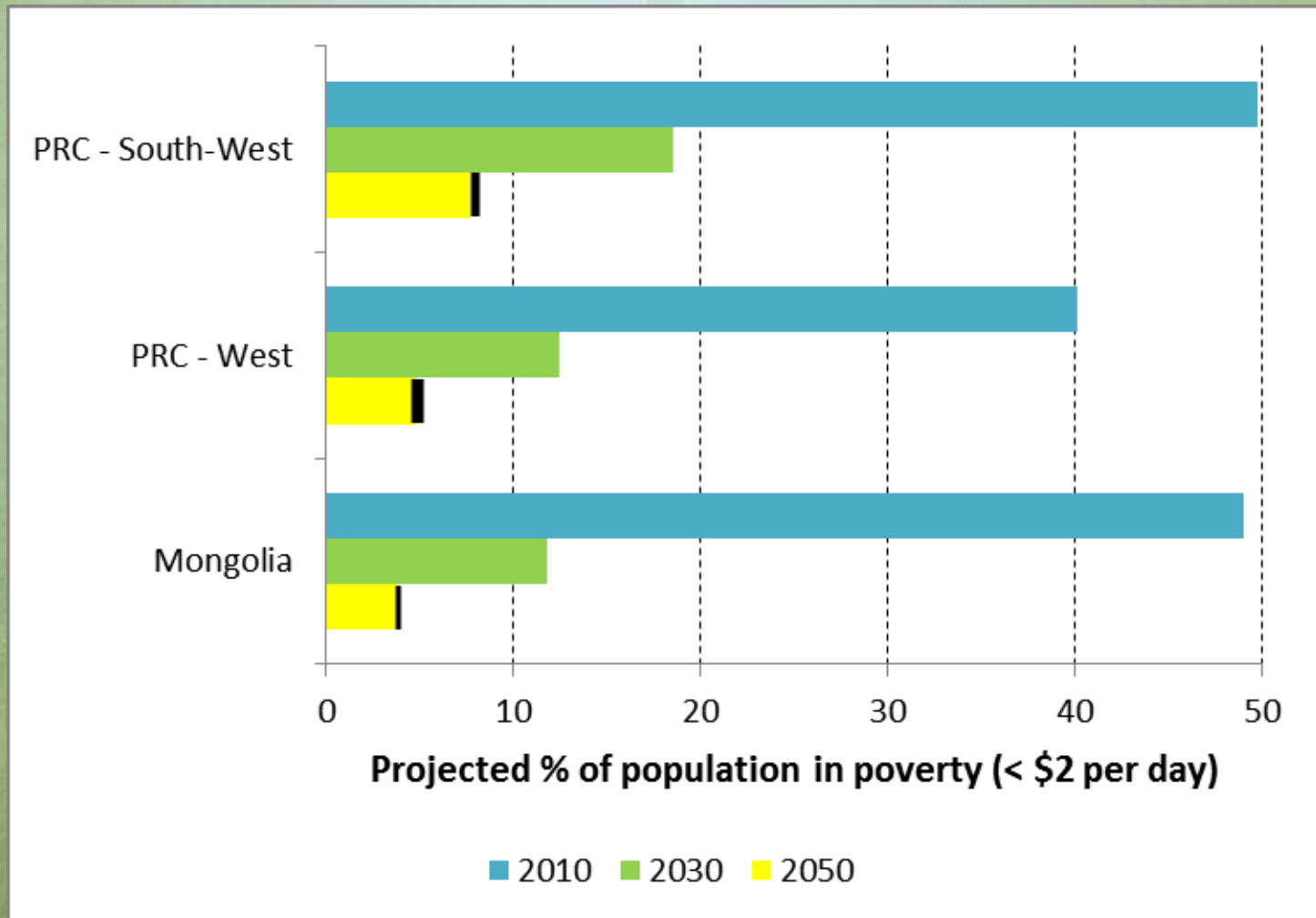


*Impact of climate change on crop supply and demand after adaptation in East Asia, 2050*

# Climate change and poverty

- Rapid economic growth will reduce poverty by over 80% in all of the major regions of the PRC as well as in Mongolia without climate change in 2050.
- Projected increases in precipitation variability due to climate change in the PRC and Mongolia may increase the poverty in the two countries by a very small amount.
- The projected increase in food prices up to 2050 without climate change is likely to result in an overall decrease in rural poverty in the PRC.
- This effect may be partly offset by a reduction in food production due to climate change.

## The impact of climate change on poverty indices in China and Mongolia is small relative to the benefits of economic growth



*Impact of climate change on poverty, 2050*





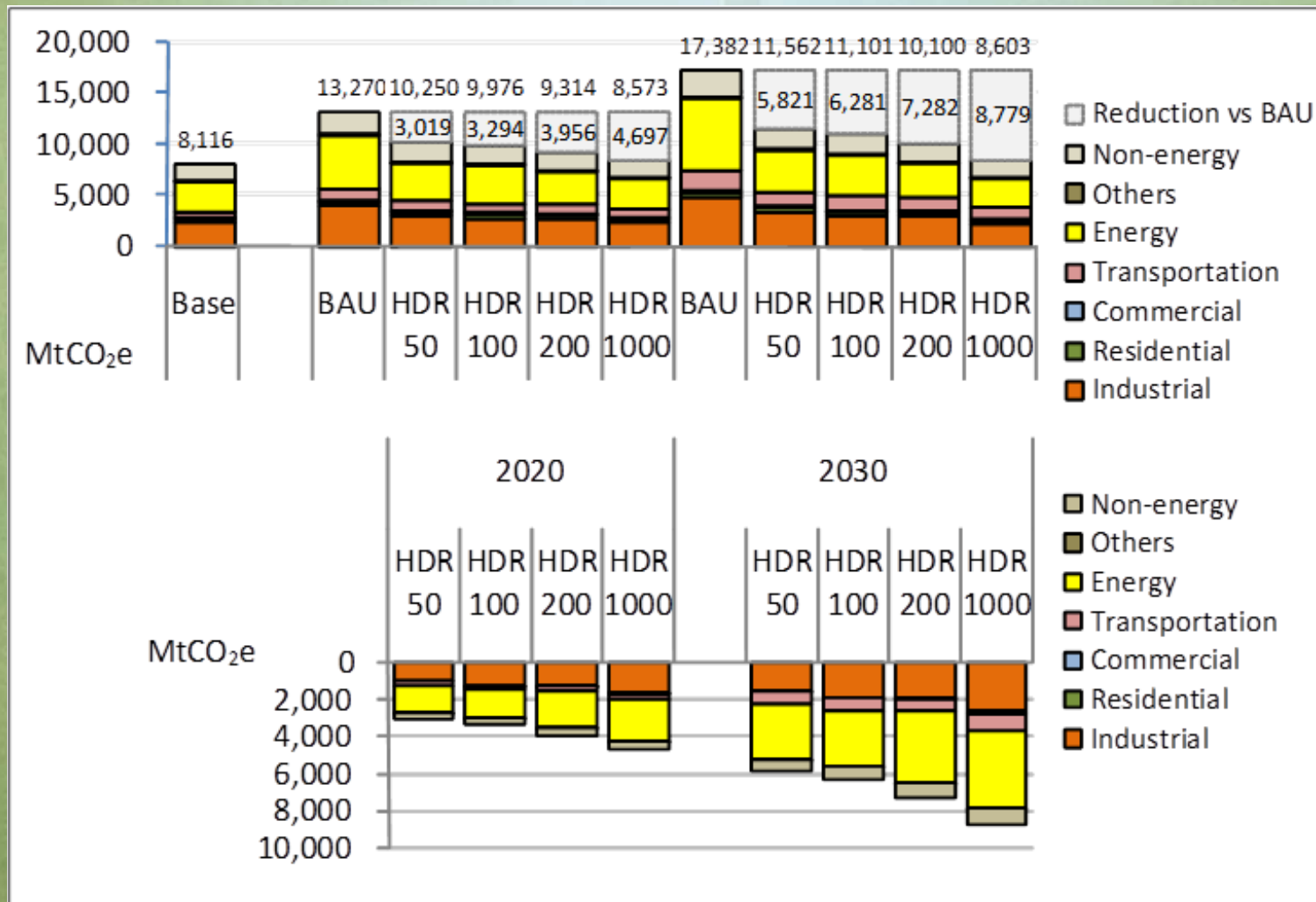
# **Part 4**

## **Mitigation strategies**

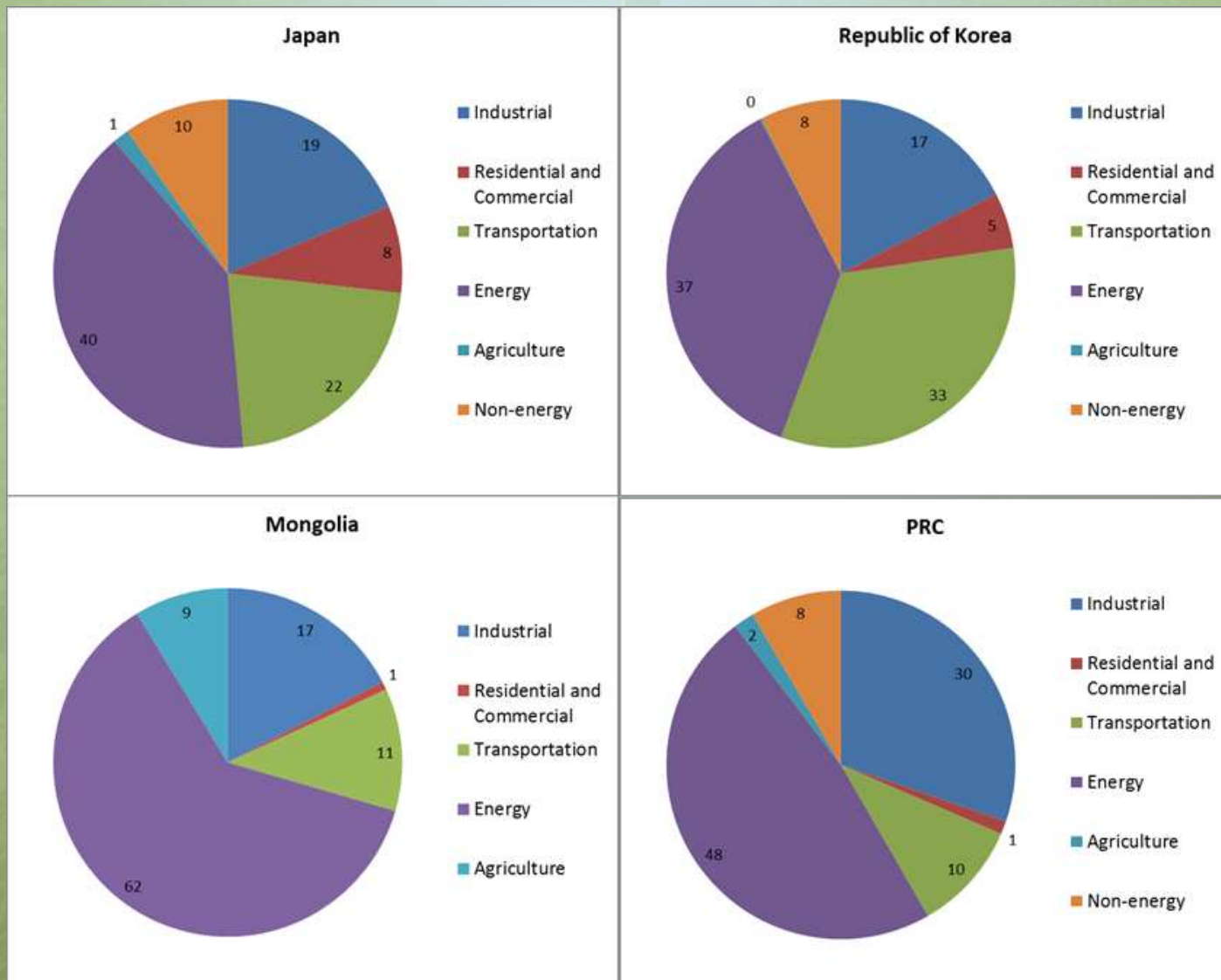
# Abatement options

- The maximum abatement potential in East Asia is large.
- About 70% of the abatement potential has a marginal abatement cost of less than \$100 per tCO<sub>2</sub>e.
- Some of the abatement options in East Asia are "win–win" – i.e. they have a negative abatement cost.
- A 5-year delay in reducing emissions from the power sector in the PRC lowers potential abatement by up to 15% in 2030.
- Mitigation efforts in the PRC will reduce its dependence on imports of coal and oil, but will increase its dependence on imports of gas.
- Mitigation can reduce health costs from air pollution.
- A regional carbon market would be cost-effective in East Asia.

# CO2 emissions in the PRC in 2030 can be reduced by more than 33% at a cost of \$100 per tonne



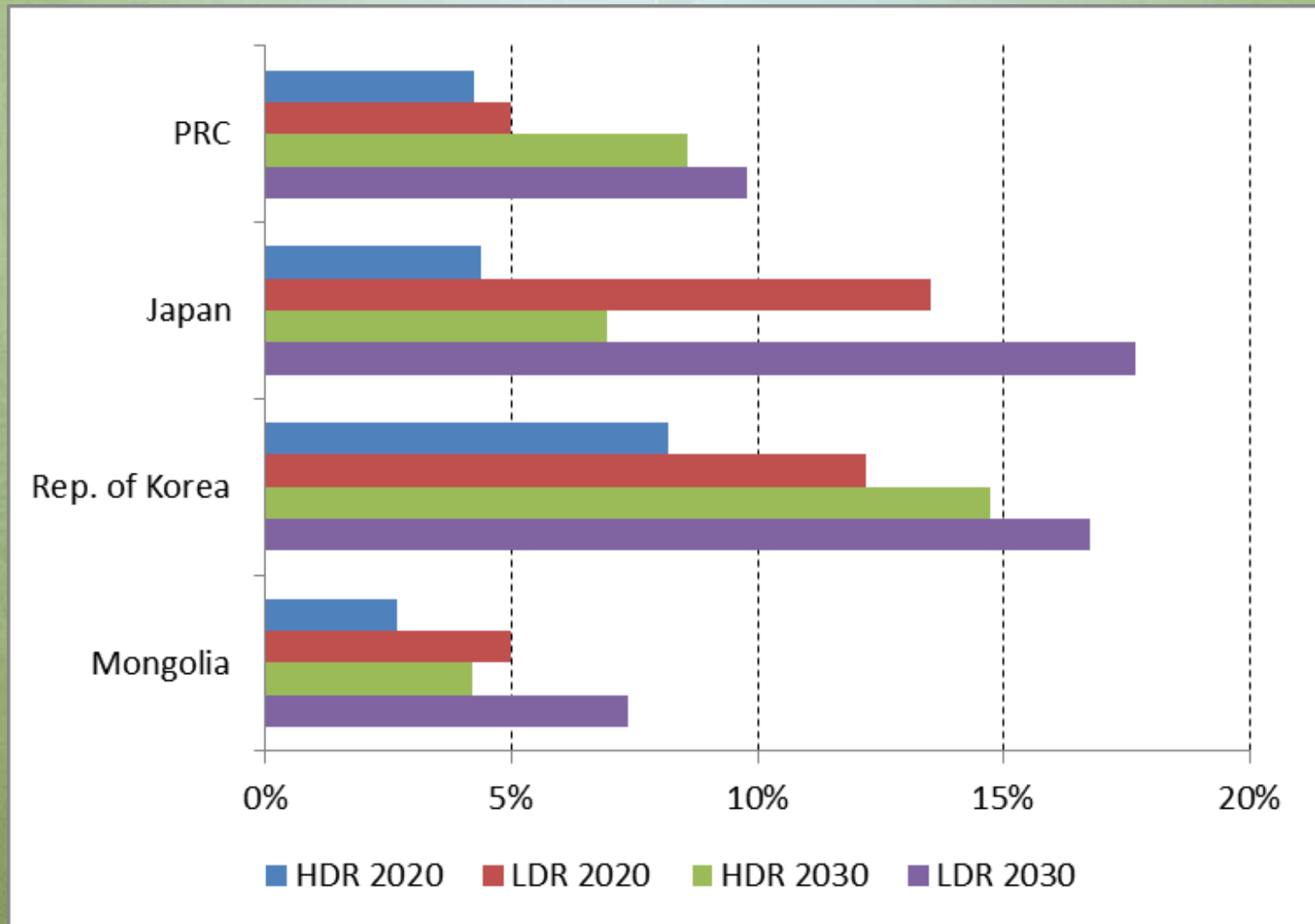
# The main opportunity to reduce emissions in East Asia is in the power sector followed in the PRC by the industrial sector



*Composition of abatement potential in 2030 (High discount rate, MAC < \$1,000 per tCO<sub>2</sub>e)*



**“Win-win” (negative cost) abatement could reduce CO2 emissions by up to 10% in the PRC and up to 18% in Japan and Korea**



***Negative cost abatement as % of Business As Usual (BAU) emissions***

# Opportunities for low cost abatement include advanced coal-fired power plants, gas furnaces, vehicles using gas, more efficient lighting and electric motors

|       | Japan  | Korea, Rep. of   | PRC   | Mongolia  |
|-------|--|--|---|---|
| High  | [E] Photovoltaic, hydro<br>[I] Boiler (renewable)<br>[T] Hybrid car (diesel/gas)<br>[RC] Gas/coal stove/coal boiler (space heating)                      | [E] Photovoltaic, wind power 3<br>[I] Boiler (renewable)<br>[RC] Gas/coal stove/coal boiler (space heating)              | [E] Hydro, wind power 3, wind + storage<br>[I] Boiler (renewable)<br>[T] Hybrid car (gas, diesel)/bus, efficient gas car<br>[RC] AC, biomass/coal stove/coal boiler (space heating) | [E] Hydro, wind + storage<br>[I] Boiler (renewable)<br>[T] Hybrid truck/car (gas, diesel)/bus, efficient gas car<br>[RC] AC, biomass/coal stove/coal boiler (space heating) |
| \$100 |  |  |   |   |
| Mid   | [E] Biomass, wind power, @s (NEW, 1,700)<br>[I] Efficient gas furnace<br>[T] Biofuels  | [E] Biomass, wind power 2, coal (SC + CCS)<br>[I] More efficient steel processes<br>[T] Biofuels, hybrid bus             | [E] Gas (NEW, 1,700), wind power 2<br>[I] More efficient steel processes<br>[T] Biofuels  | [E] Coal (SC + CS), wind power, gas (NEW, 1,700)<br>[I] More efficient steel processes<br>[T] Biofuels<br>[RC] Gas stove (space heating)                                    |
| \$0   |  |  |   |   |
| Low   | [E] Coal (SC + CCS)<br>[I] Efficient gasfurnace, advanced motors<br>[T] Efficient truck/ bus, natural gas truck, efficient rail<br>[RC] CFL, FL lighting | [I] Efficient gas furnace<br>[T] Efficient truck, hybrid truck/car (gas, diesel, efficient rail<br>[RC] CFL, FL lighting | [E] Coal (USC + CCS)<br>[I] Advanced motors<br>[T] Natural gas trucks, efficient trucks, efficient rail<br>[RC] CFL, FL lighting  | [I] Advanced motors<br>[T] Efficient/electric rail, efficient trucks<br>[RC] CFL, FL lighting   |

**Ranking of abatement options by country**  
 (High discount rate, MAC < \$1,000 per tCO<sub>2</sub>e)

# **Part 5**

## **Policy Responses**

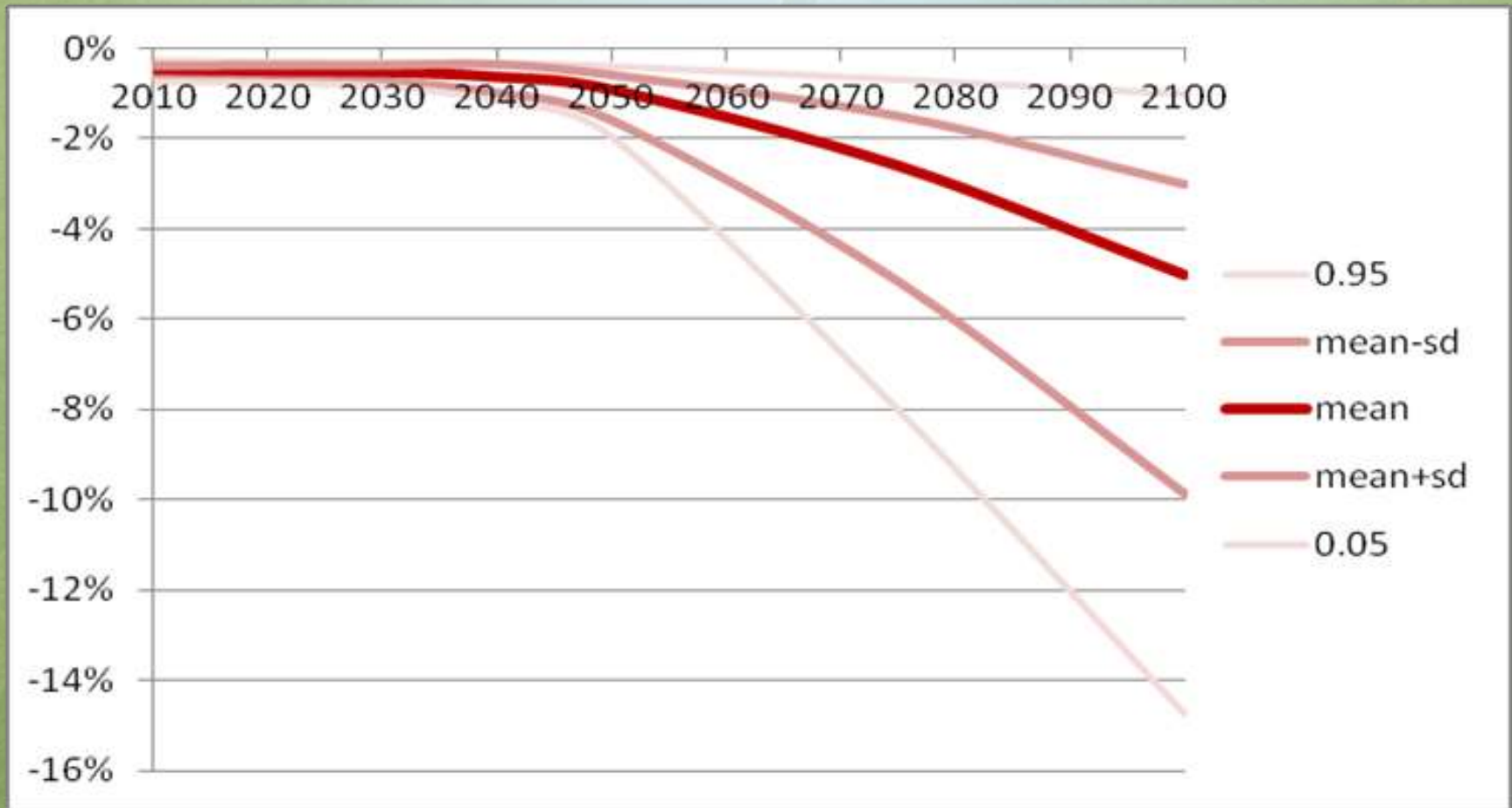


# Developing a long term strategy

- Under the BAU scenario the average losses in East Asia due to climate change could amount to 5.3% of GDP by 2100.
- Adaptation can reduce the damage due to climate change but it is not sufficient to reduce the expected cost of climate change to a low level.
- Reliance upon zero cost reductions will not prevent emissions from increasing substantially from 2020 to 2050.
- Alternative paths for reducing emissions can be derived by reference to targets for emissions and the concentration of greenhouse gases, or by setting maximum values for the marginal abatement costs which increase over time.
- Any policy strategy to address climate change has to combine mitigation and planned adaptation as well as taking into account residual damage costs

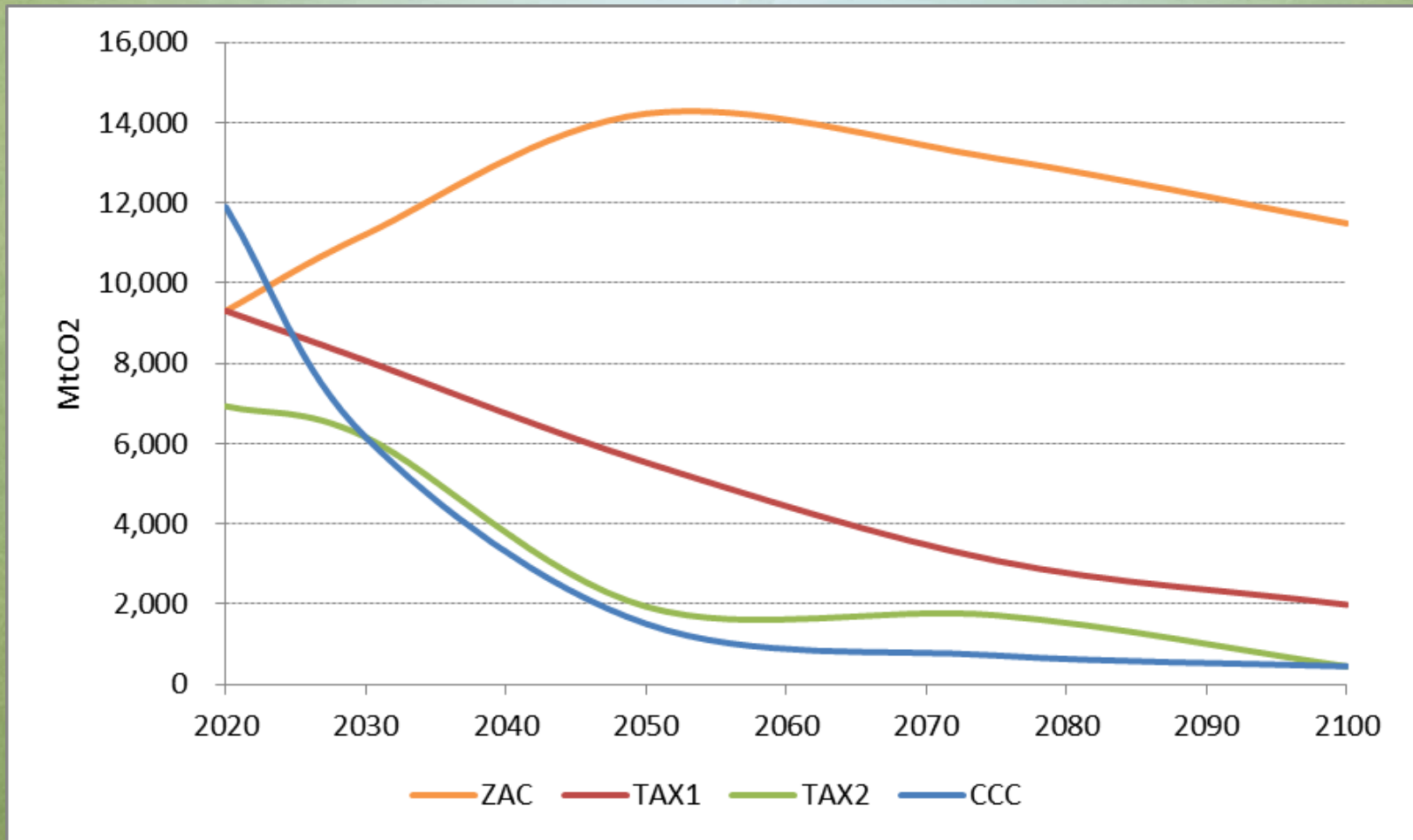


## Doing nothing about climate change could cost 5% of East Asia's GDP but with a very high uncertainty



*Uncertainty about damages due to climate change with no adaptation  
(% of GDP for East Asia)*

**Relying upon negative cost abatement is not sufficient. Putting a price on carbon that increases gradually over time (TAX1 / TAX2) can get close to the Copenhagen scenario by 2100**



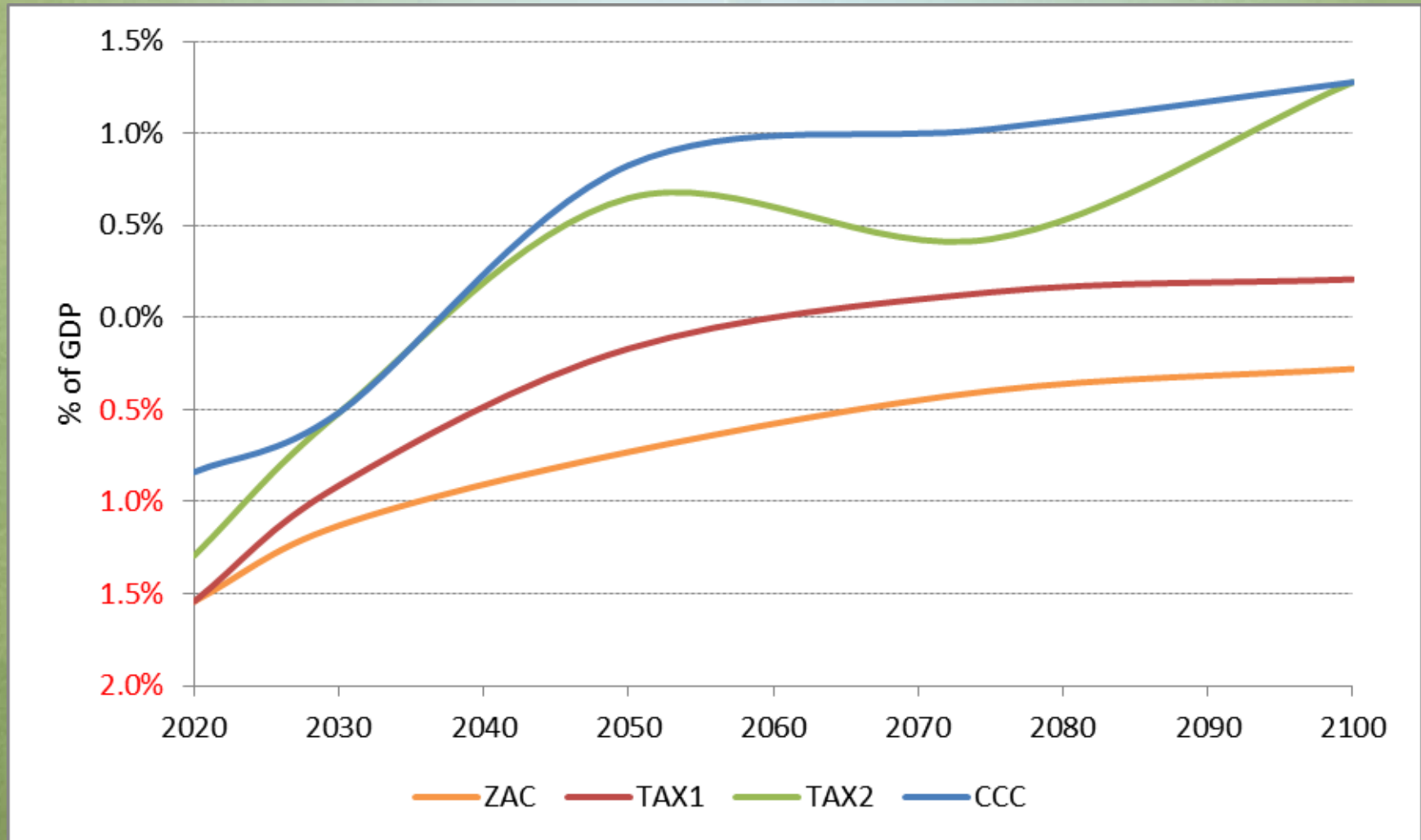
***Total energy-related emissions of CO<sub>2</sub> for East Asia under alternative strategies  
(million tonnes of CO<sub>2</sub>)***

Adapting to projected climate conditions in 2100 should cost less than 1% of GDP for East Asia, but residual damage might still be up to 2% of GDP with a reduction in CO2 emissions

| Emission Scenario             | Adaptation Targets | Average Annual Cost of Planned Adaptation |       | 90% Confidence Range for Cost of Planned Adaptation (% GDP) |      | Residual damage in 2100 |
|-------------------------------|--------------------|---|-------|---|------|-------------------------|
|                               |                    | \$ billion                                | % GDP | Low   | High | (% GDP)                 |
| A. Adaptation to 2050 climate |                    |   |       |   |      |                         |
| BAU                           | 2.5° C, 0.30 m SLR | 77  | 0.2   | 0.1   | 0.4  | 2.3                     |
| ZAC                           | 2.3° C, 0.30 m SLR | 71  | 0.2   | 0.1   | 0.4  | 1.2                     |
| TAX1                          | 2.2° C, 0.30 m SLR | 68  | 0.2   | 0.1   | 0.3  | 0.9                     |
| TAX2                          | 2.1° C, 0.30 m SLR | 64  | 0.2   | 0.1   | 0.3  | 0.6                     |
| CCC                           | 1.7° C, 0.26 m SLR | 51  | 0.1   | 0.1   | 0.3  | 0.2                     |
| B. Adaptation to 2100 climate |                    |   |       |   |      |                         |
| BAU                           | 4.5° C, 0.70 m SLR | 140                                       | 0.4   | 0.2   | 0.7  | 1.6                     |
| ZAC                           | 4.0° C, 0.65 m SLR | 124                                       | 0.4   | 0.2   | 0.6  | 0.8                     |
| TAX1                          | 3.3° C, 0.60 m SLR | 102                                       | 0.3   | 0.1   | 0.5  | 0.7                     |
| TAX2                          | 3.1° C, 0.60 m SLR | 97  | 0.3   | 0.1   | 0.5  | 0.4                     |
| CCC                           | 2.5° C, 0.55 m SLR | 76  | 0.2   | 0.1   | 0.4  | 0.1                     |

***Cost of planned adaptation for East Asia (Average costs as % of GDP)***

Combining adaptation with mitigation using an increasing carbon price can keep the net cost of responding to climate change below 0.5% of GDP (TAX1)



***Total costs of mitigation strategies for East Asia (% of GDP)***



Setting aside opportunities for negative cost abatement there is a trade-off between adaptation and mitigation. The best option is to act early, combining both adaptation and mitigation.

| Emission Scenario             | Average annual costs as % of GDP of |            |                 |       |
|-------------------------------|-------------------------------------|------------|-----------------|-------|
|                               | Mitigation                          | Adaptation | Residual Damage | Total |
| A. Adaptation to 2050 climate |                                     |            |                 |       |
| BAU                           | 0.0                                 | 0.2        | 1.2             | 1.4   |
| ZAC                           | 0.0                                 | 0.2        | 0.6             | 0.8   |
| TAX1                          | 0.4                                 | 0.2        | 0.5             | 1.0   |
| TAX2                          | 0.9                                 | 0.2        | 0.3             | 1.4   |
| CCC                           | 1.1                                 | 0.1        | 0.1             | 1.3   |
| B. Adaptation to 2100 climate |                                     |            |                 |       |
| BAU                           | 0.0                                 | 0.4        | 0.8             | 1.2   |
| ZAC                           | 0.0                                 | 0.4        | 0.4             | 0.8   |
| TAX1                          | 0.4                                 | 0.3        | 0.4             | 1.0   |
| TAX2                          | 0.9                                 | 0.3        | 0.2             | 1.4   |
| CCC                           | 1.1                                 | 0.2        | 0.1             | 1.4   |

***Combining mitigation and adaptation in East Asia (Average costs as % of GDP)***

# Climate policies

A green wind turbine is positioned in the center of the slide, appearing to grow out of a green pot. The background is a solid green color.

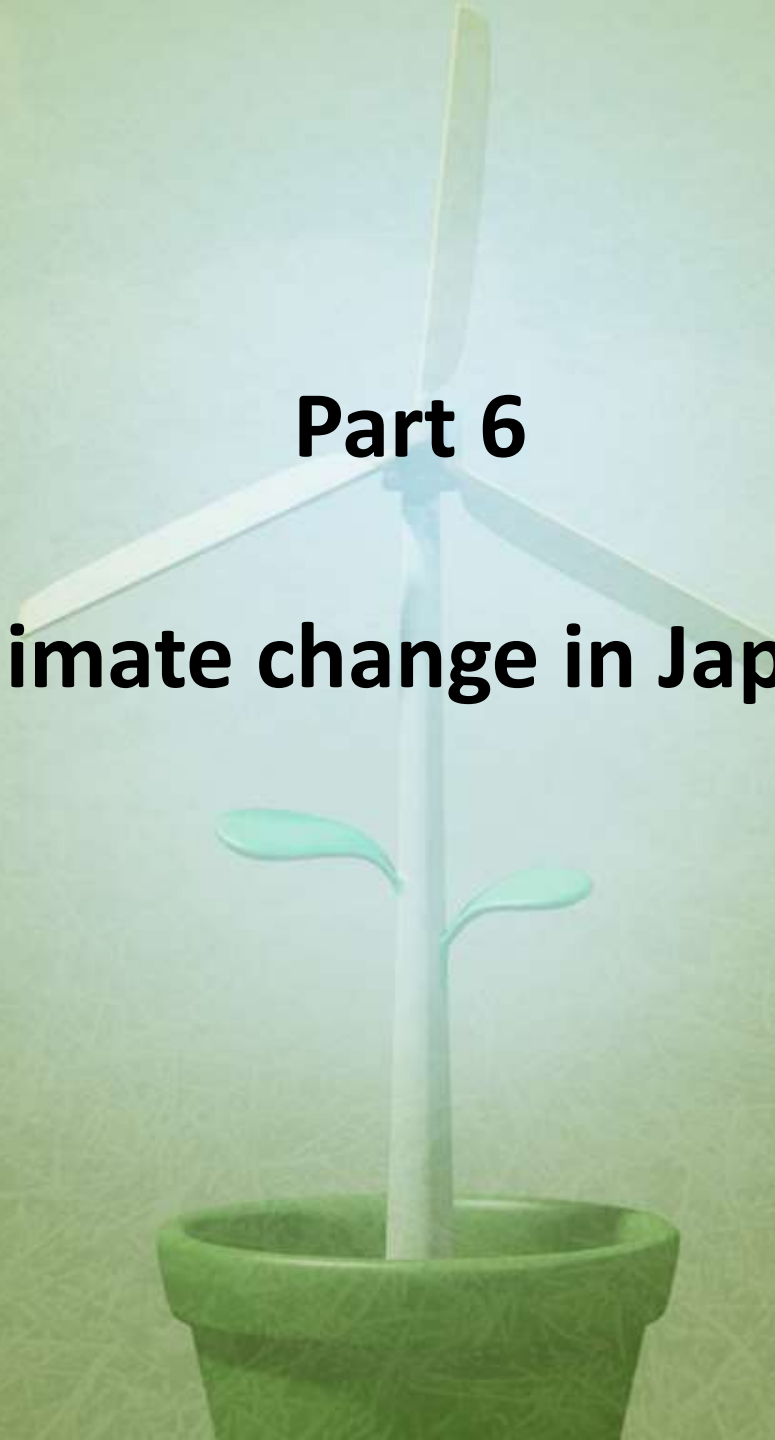
- Countries in East Asia have adopted and are implementing ambitious policies and programs to address climate change
- Climate change policies and programs in East Asia have some common strengths.
- Market arrangements to price carbon, via either carbon trading or carbon taxes, remain underdeveloped.
- The scale of funding for research and development and the level of innovation mean that Japan, the Republic of Korea, and the PRC are well-placed to develop new low-carbon technologies.
- There are a number of possible areas of regional cooperation, most notably a regional emissions trading scheme.

# Regional cooperation to reduce emissions

- Develop a regional emissions trading scheme
  - The benefits of pooling emission reductions through a trading scheme should be large
- Pool expertise in planning adaptation
  - Provide support to Mongolia for adaptation
- Create an East Asian climate network
  - Current initiatives could be expanded to enhance the benefits of cooperation in collecting and analysing information and experience
- Promote more accurate and transparent reporting of climate and emissions data

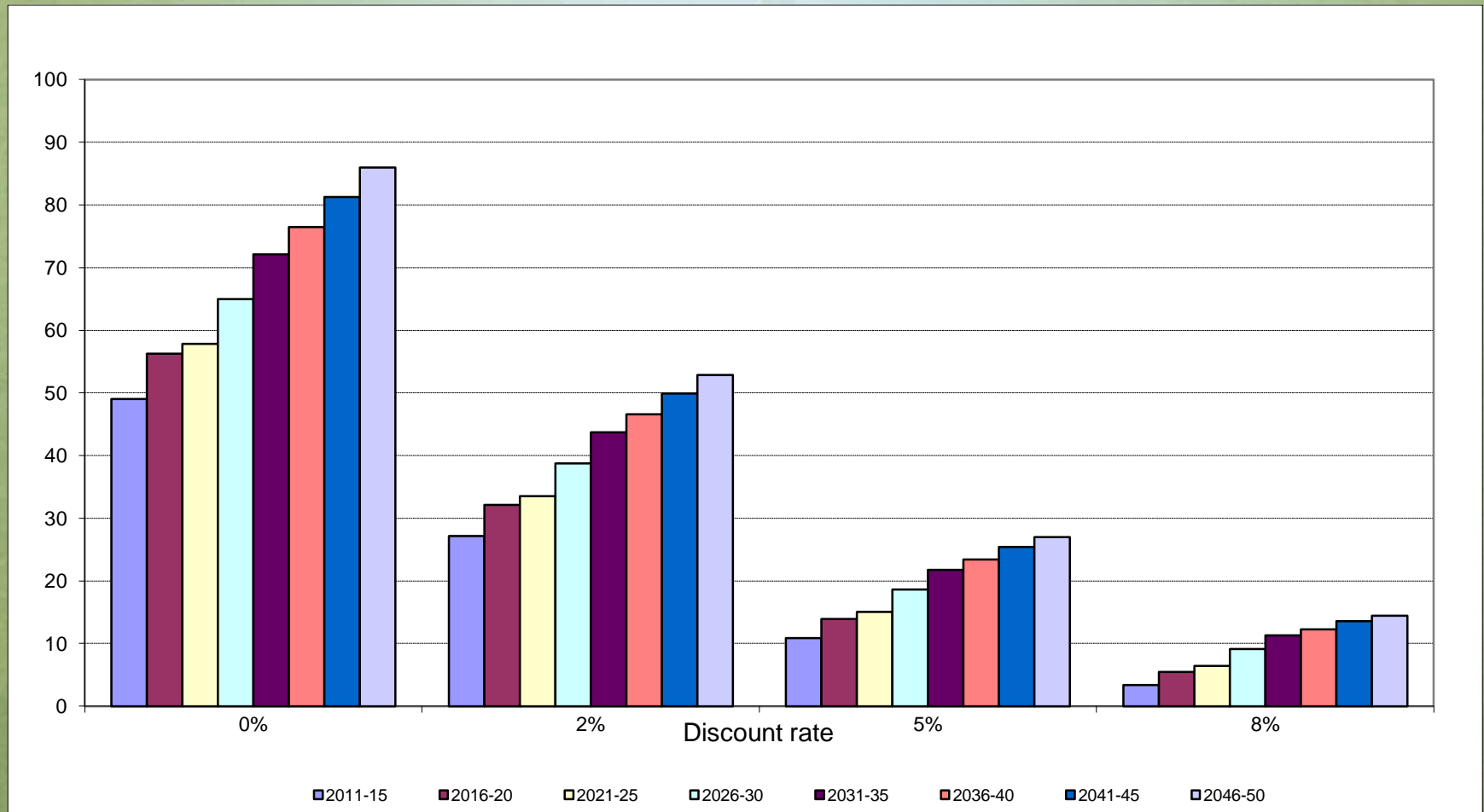
## **Part 6**

# **Climate change in Japan**



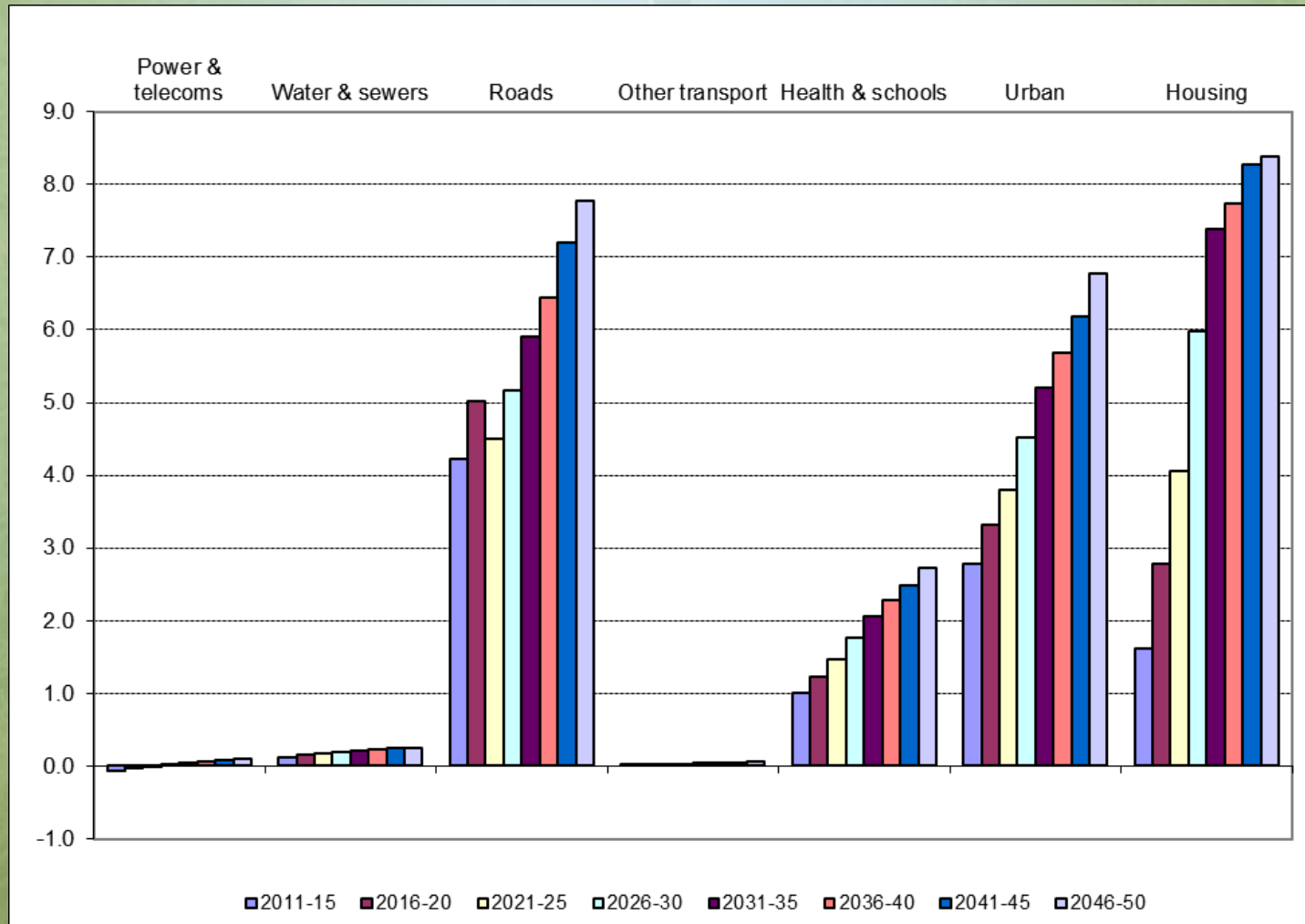


# Planned adaptation (climate-proofing) for all infrastructure in Japan is justified at discount rates up to 8%



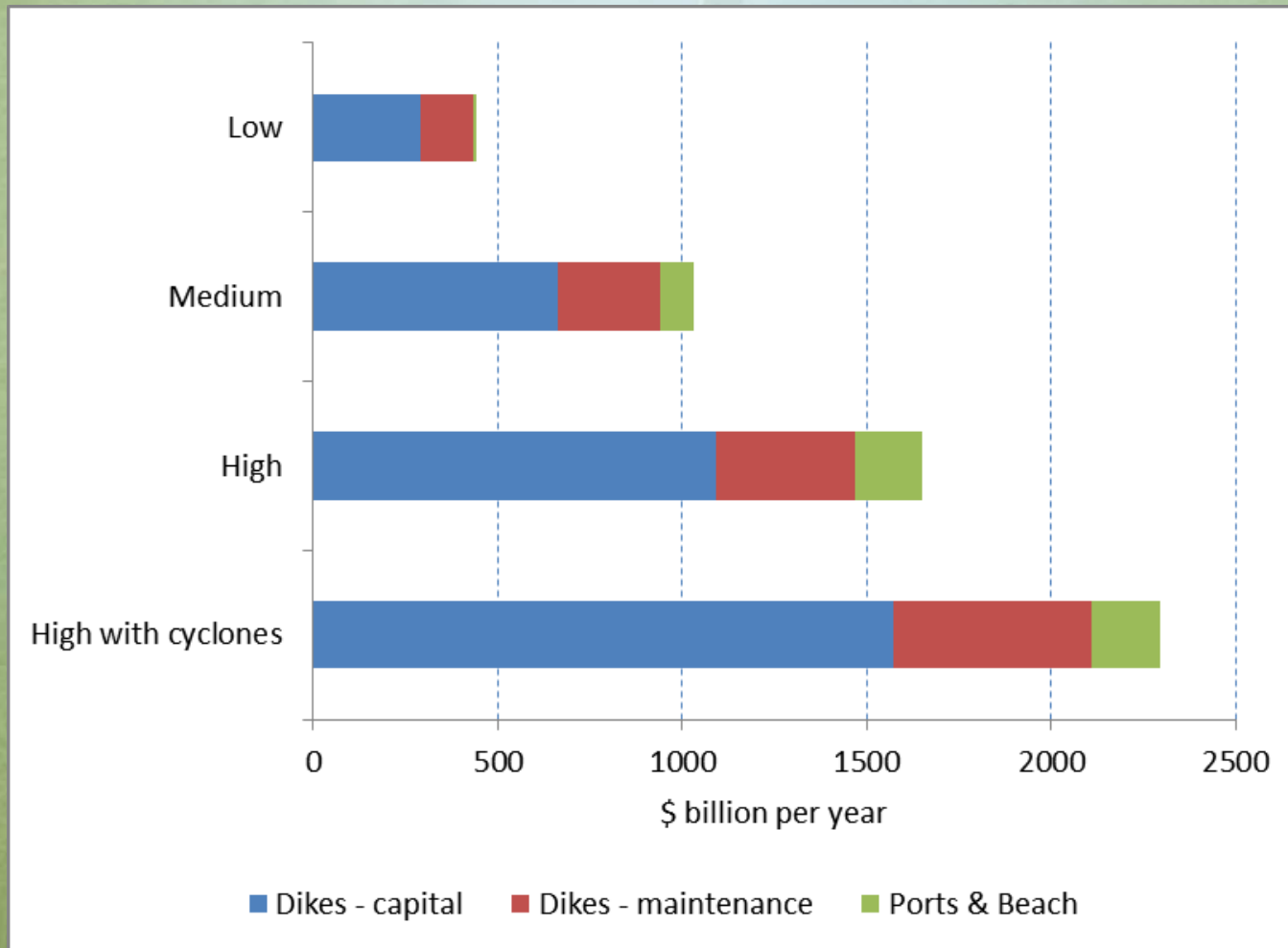
*Net benefits of planned adaptation for all infrastructure in Japan by discount rate (\$ billion)*

# The priorities for climate-proofing in Japan are roads, urban infrastructure and buildings/housing



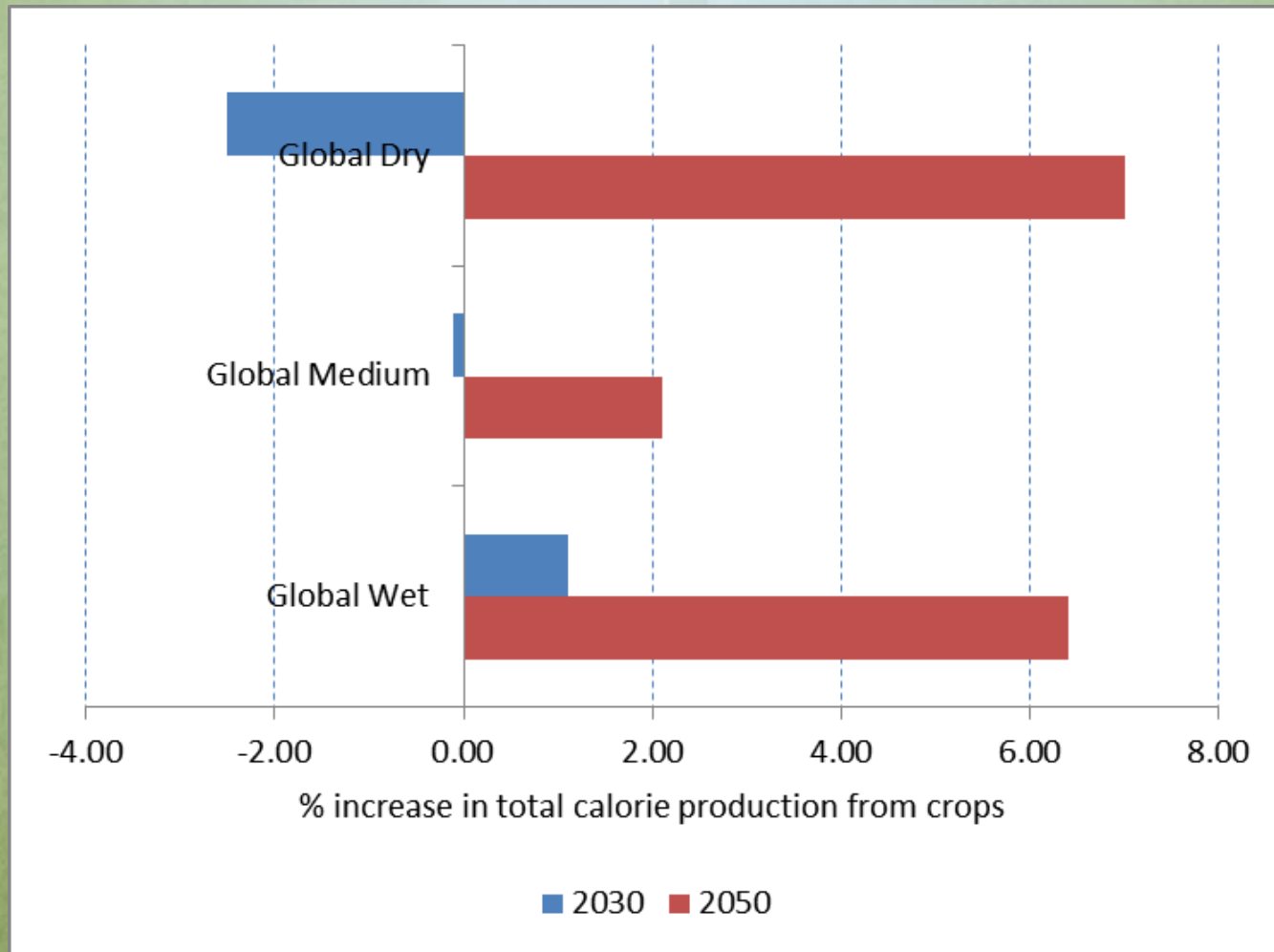
***Net benefit of planned adaptation for Japan by sector  
(\$ billion, discount rate 5%)***

**The cost of coastal adaptation is up to \$2.3 billion per year**  
**Almost all of the cost is for building & maintaining sea dikes.**



***Average cost of coastal adaptation for Japan***  
***(\$ million per year 2010-2050)***

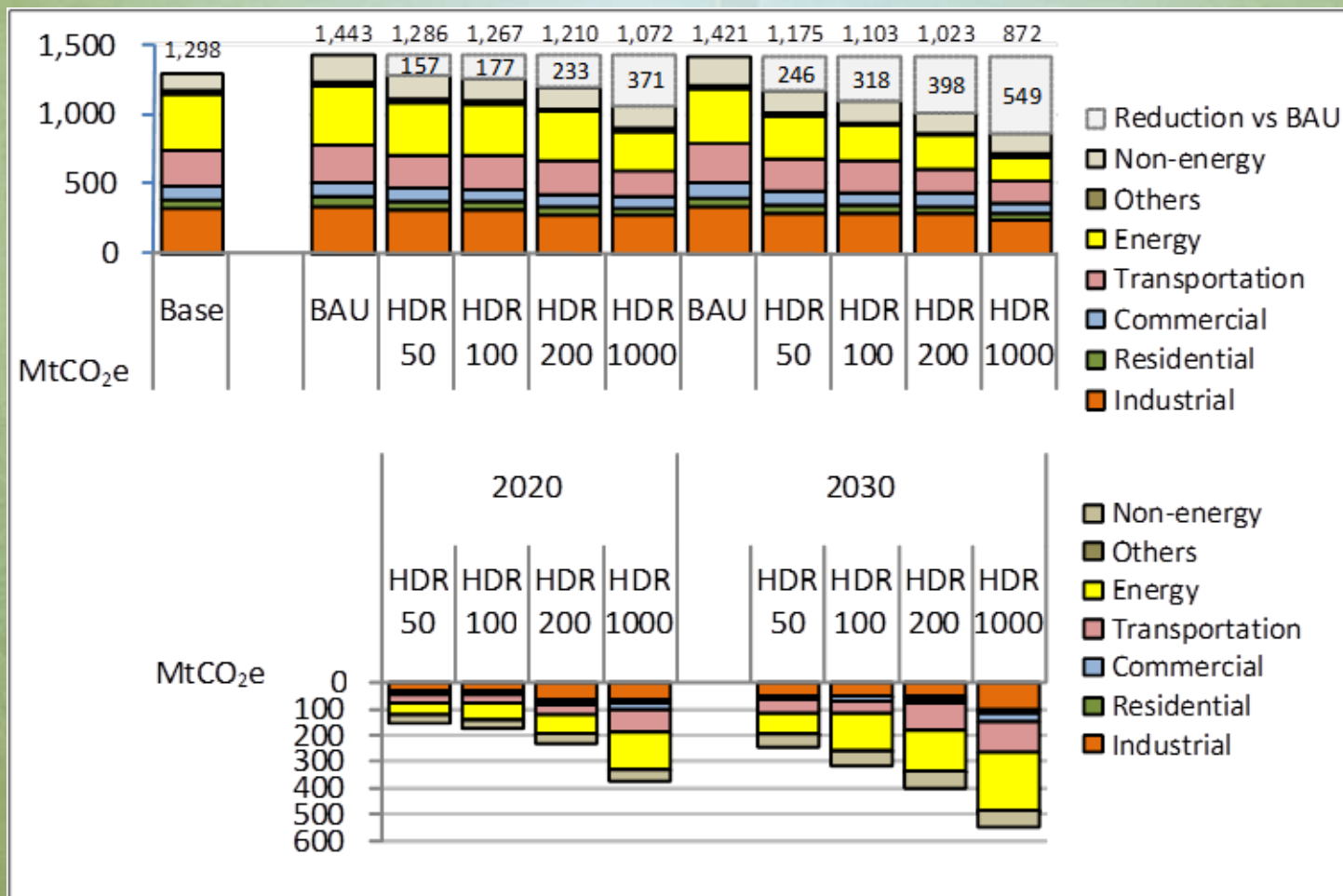
**Total crop production may decline by a small amount up to 2030 but it will increase by 2-7% up to 2050**



***Increase in crop production for Japan by climate scenario***

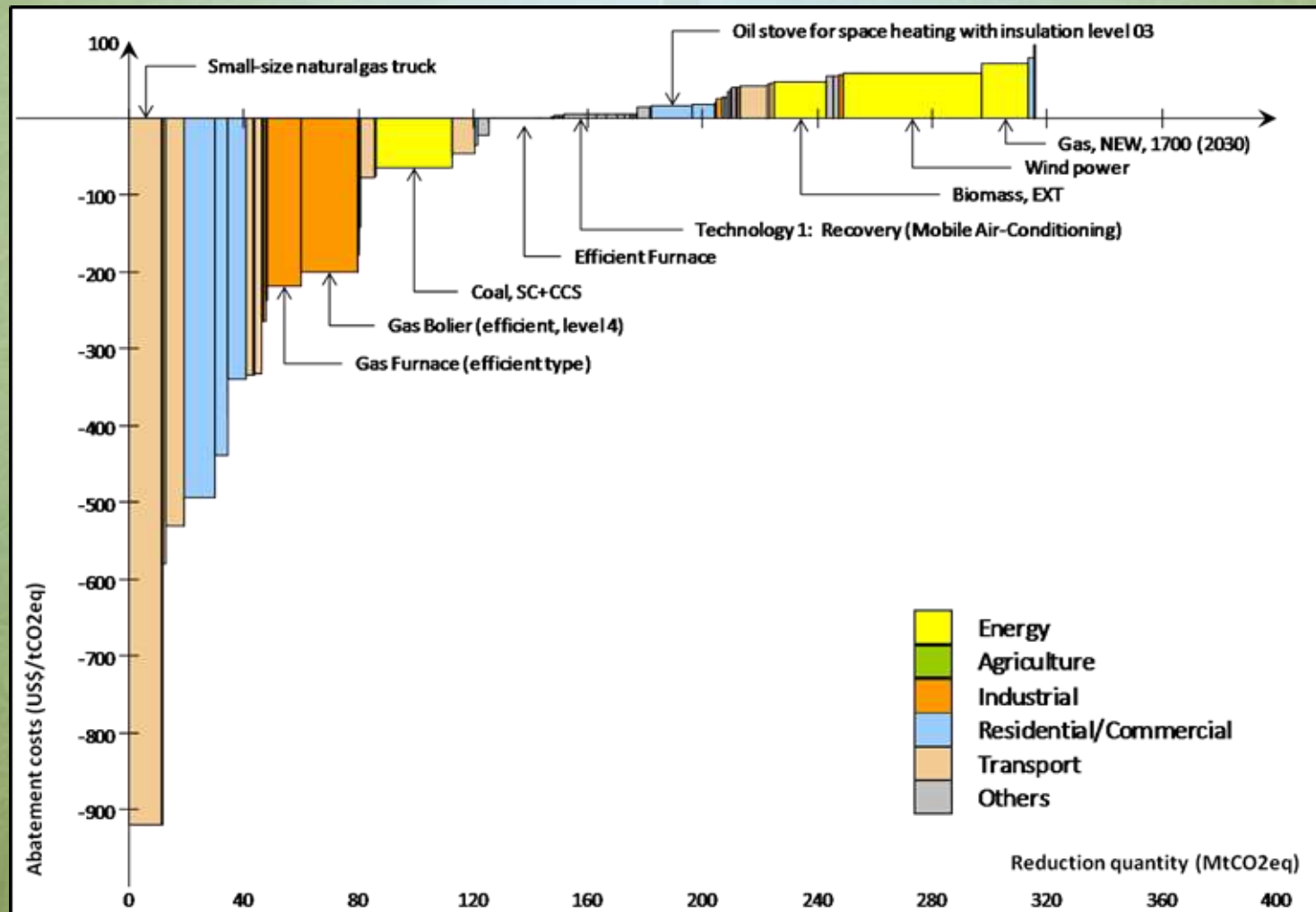


**There is an abatement potential of 39% by 2030.  
But costs rise very greatly above 22% abatement.**



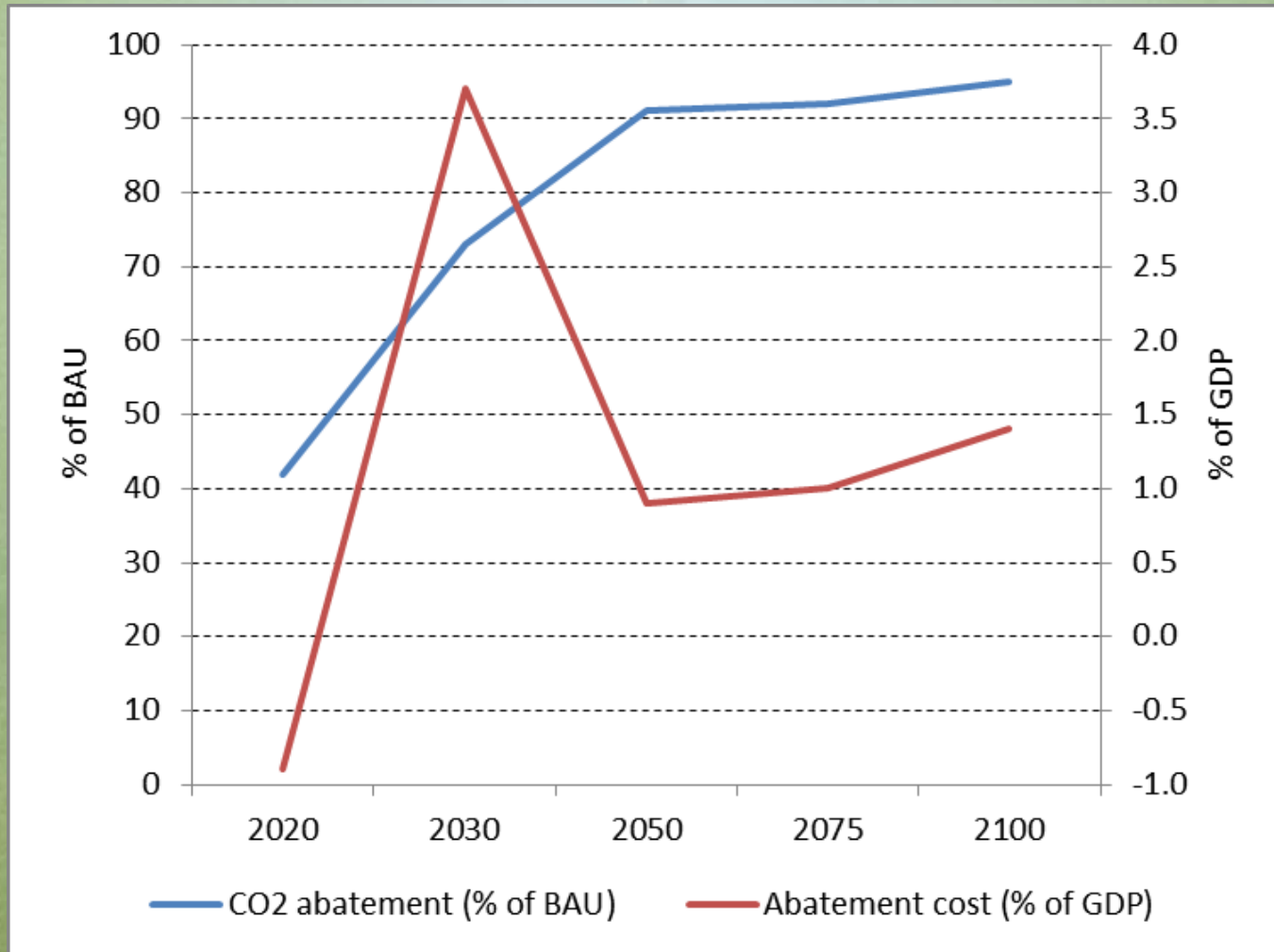
***Abatement potential for Japan in 2030  
(High discount rate, ceiling \$1000 per tCO<sub>2</sub>e)***

The main opportunities for zero and low cost abatement are in transport, housing and industry



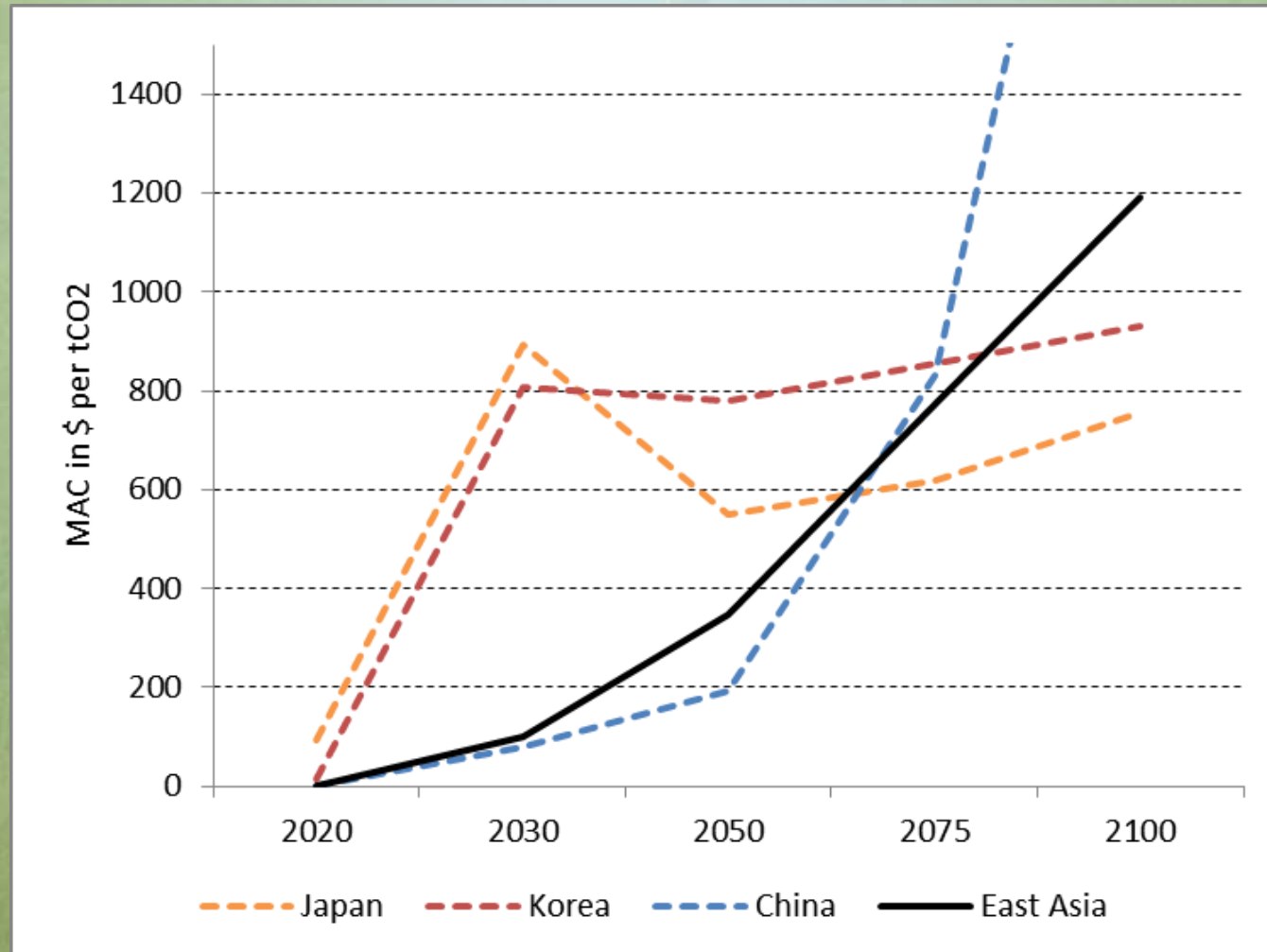
**Marginal abatement cost curve for Japan in 2030**  
(High discount rate, ceiling \$100 per tCO<sub>2</sub>e)

The costs of meeting the Copenhagen-Cancun scenario are very unevenly distributed over time and are up to 4% of GDP in 2030



**Abatement targets and costs under the CCC scenario for Japan**

Marginal abatement costs differ widely across countries.  
The savings from implementing an East Asia pool may be large.



Marginal abatement costs under the CCC scenario with or without East Asia pool  
(\$ per tCO<sub>2</sub>)



# Summary messages: East Asia

- The cost of adapting to climate change are outweighed by the cost of inaction.
- Adaptation and mitigation policies should not be examined in isolation. Strategies must consider the combined effects of mitigation and planned adaptation.
- Up to 20% of the mitigation potential in the region generates a positive economic return without consideration of climate change.
- Regional cooperation pays dividends. Pooling emission targets via a regional carbon could reduce overall costs by 25% - or more.

# Summary messages : Japan

- Each country must examine and plan for their specific circumstances.
- The priorities for Japan are:
  - Climate-proof infrastructure including roads & housing
  - Increase maximum wind speeds by 5 m/s
  - Invest in coastal protection
  - Abatement for transport, buildings & industry
- The costs of meeting abatement targets may be high
- The potential benefits from participation in an East Asia CO<sub>2</sub> pool would be substantial

**THANK YOU!**

**谢谢**

**ありがとうございます**

**감사합니다.**

**Баярлалаа**

**For further questions, pls contact:**

**Jörn Brömmelhörster , Asian Development Bank ([jbrommelhorster@adb.org](mailto:jbrommelhorster@adb.org))**