アジア太平洋統合モデルによる地球温暖化の統合評価
- Integrated Assessment of global warming using the Asian Pacific Integrated Model (AIM) -

Goshi Fujimoto,
first-year master's degree student
at Division of Ocean and Atmospheric Science
Graduate School of Environmental Earth Science,
HOKKAIDO UNIVERSITY

Introduction article

- I will introduce following article at today's presentation which is a preliminary practice for the "Introduction Article Seminar" on December.
  - Matsuoka, Y., Kainuma, M., Morita, T., 1995: Scenario analysis of global warming using the Asian Pacific Integrated Model (AIM). Energy Policy 23 (4/5), 357-371.

Content

1. Introduction

1.1 Background

- Mechanism of climate change
  - Carbon circulation, aerosols
- Prediction of economic development
  - Long-scale prediction
- Estimation of preventive measures
  - Combination, global measures, allocation of measure time
- Assessment of the influence by climate change
  - Reduction of Agricultural productions and rise of these prices
- Adaptation of society to climate change
  - Mitigation of damage by reasonable human provisions

1.2 Purpose

- **Many unresolved issues around global warming**

The latter research is more necessary for policy makers who consider the process of policy development than former one.

  - **Human activities**
    - **Population growth, economic development, technological innovation, and so on.**

2. Scenario

- **Premise-based scenarios**
  - How the fundamental factors that cause global warming will change?
- **Global warming scenarios**
  - The quantity of greenhouse gas emissions
- **Impact scenarios**
  - Influences of climate change on the natural environment and socioeconomic systems
- **Policy scenarios**
  - Appropriate times for the introduction of suitable policies to stem global warming.
- **Cost scenarios**
  - Estimates of the increase in the socioeconomic load, in case policy scenarios are adopted

3. Scenario analysis

3.1 Population growth

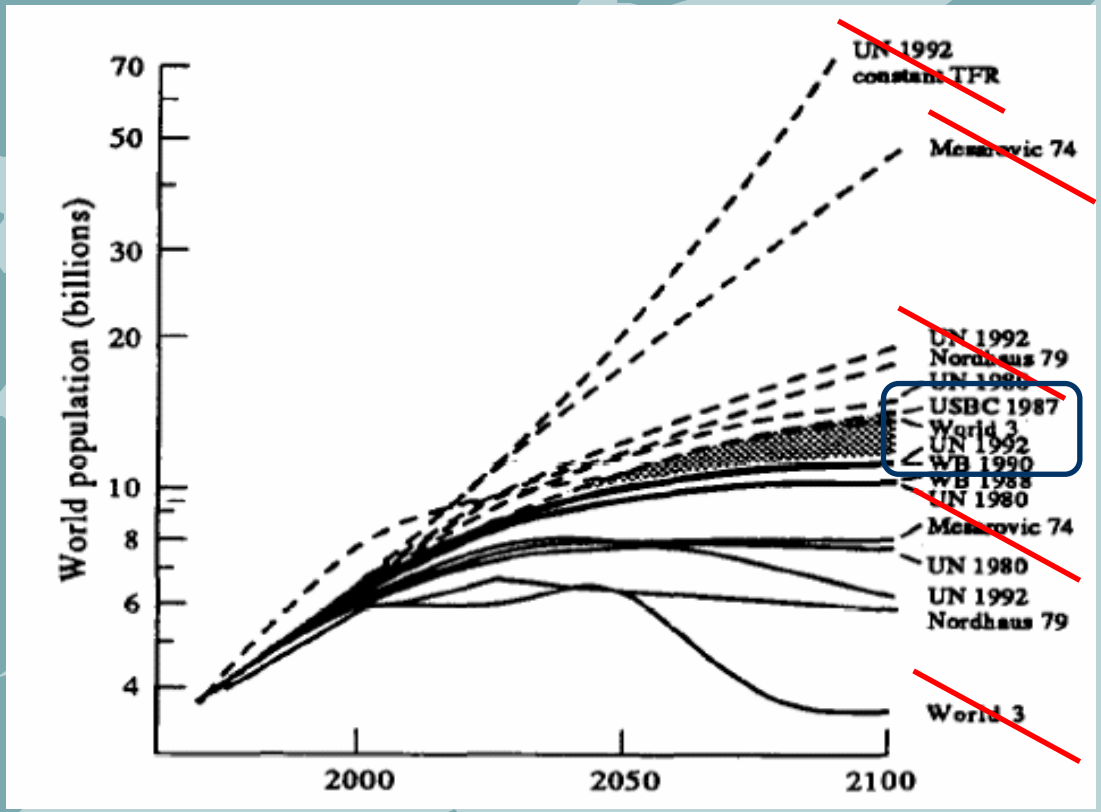

Fig. 1 Future world population estimates [Matsuoka et al., 1995]. Dotted lines show high estimates, and solid lines show low estimates. The gray area is the range assumed in this paper.

Sources: United Nations, 1992; Mesarovic and Pestel, 1974; Nordhaus, 1979; US Bureau of the Census, 1987; Meadows et al., 1972; World Bank, 1991.

Extremely unlikely!

This likelihood is also considerable.

Population policies that produce a decrease in world population are likely to engender major social problems.

Eventually, the authors adopted from the estimate of the WB 1990 to the estimate of USBC 1987 (gray area).

3.2 Economic growth

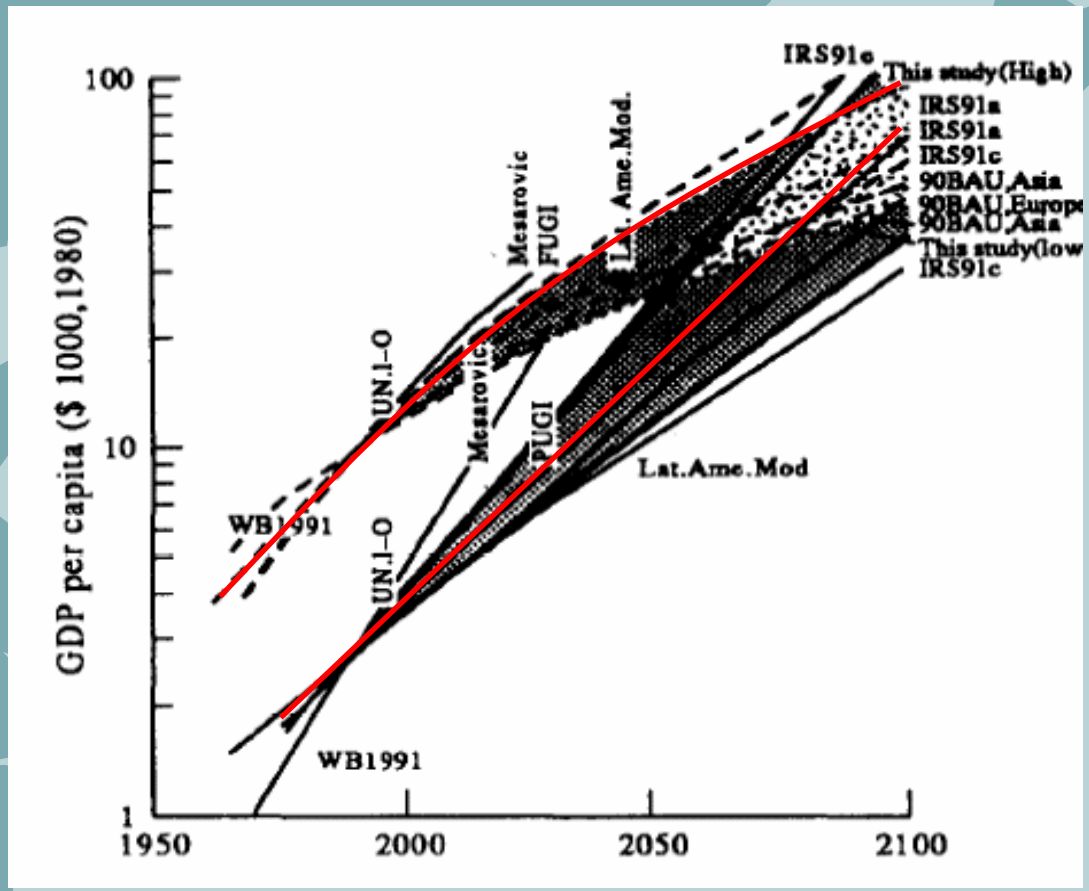

Fig. 2 Forecasts of economic growth [Matsuoka et al., 1995]. Dotted lines are OECD countries, and solid lines are South-east Asian countries excluding Japan. The shaded area denotes the range assumed in this paper.

Sources: IPCC, 1990.

- **90BAU is the business-as-usual case set by the IPCC.**
- **IRS91 is the estimate used by the IPCC in its 1991 reevaluation of emissions inventories.**
- **IRS91a is used as the standard scenario (±20%).**

3.3 The relationship between population growth and economic growth

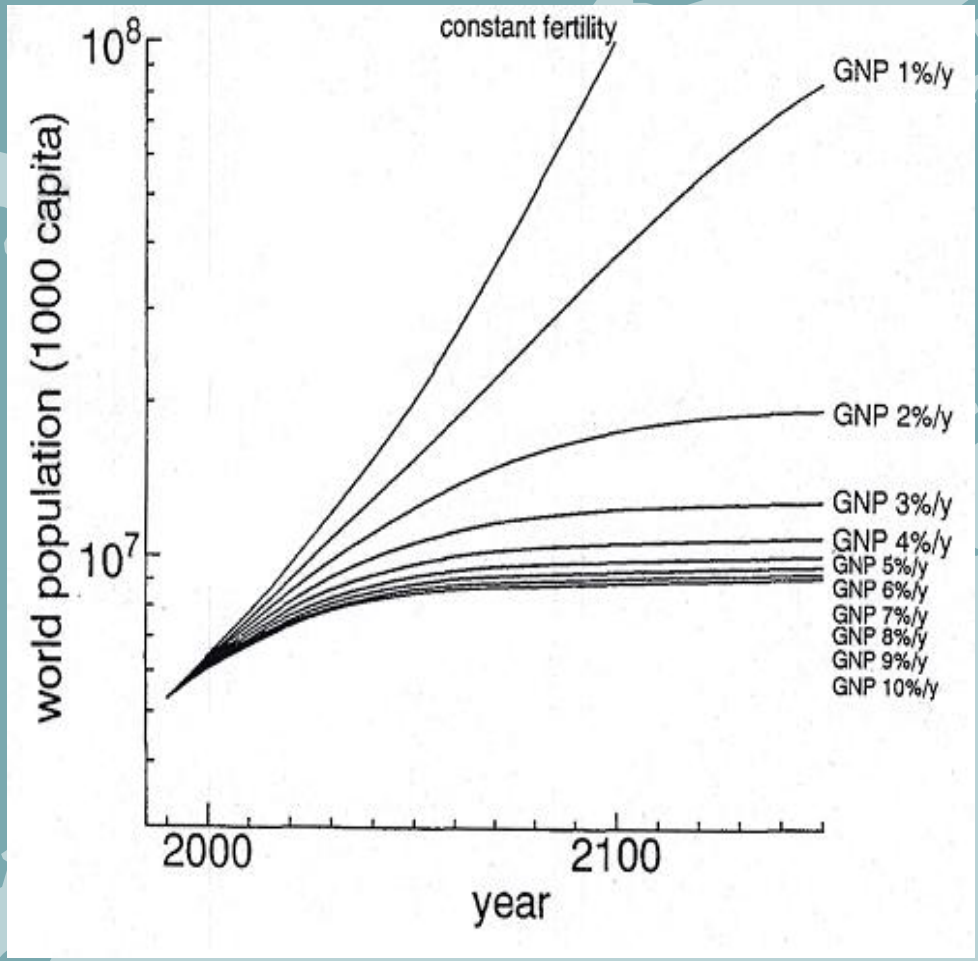

Fig. 3 World population forecasts under different values of per capita GNP [Morita et al., 1994].

- **A decrease in population growth rates in developing regions, increases the potential for saving and promotes the formation of capital [Bilsborrow, 1989].**

- **The relationship between the global Total Fertility Rate (TFP) and per capita GNP can be explained by the following equation:**

$$\Delta TFR = -\alpha \Delta \ln[\text{per capita GNP}]$$

,where α was estimated statistically to be 1.3 [Matsuoka et al., 1993].

3.4 Technological improvement

- The annual rate is between 0 and 0.5%, whereas if large energy savings are assumed, this rise to 1.0%.
- Some normative energy conservation scenarios
  - Lovins et al (1981)
    - The per capita consumption of primary energy is reduced to 22% in developed regions, and to 50% in developing regions between 1975 and 2080.
  - Goldemberg et al (1988)
    - The per capita energy consumption in developed regions is reduced to 50% and restricted to 110% in developing regions between 1980 and 2020.

Table 1 Autonomous energy-efficiency improvement (AEEI) values of typical recent energy models [Matsuoka et al., 1995].

Modelers	AEEI (per year)
From global energy models	
Edmonds *et al* (1991)	0.5–1.0%
Manne and Richels (1991)	0.0–1.0%
Vouyoukas (1991)	1.1% in OECD countries
Burniaux *et al* (1991)	1.0%
IPCC[a] (1990)	0.16% in USA (lower growth scenario) 0.46% in USA (higher growth scenario)
From feasibility studies of energy efficiency scenarios	
Lovins *et al*[a] (1981)	1.12% in developed countries 1.53% in developing countries
Goldemberg *et al*[a] (1988)	2.85% in developed countries 1.40% in developing countries

[a] Estimated.

3.5 Emissions scenarios

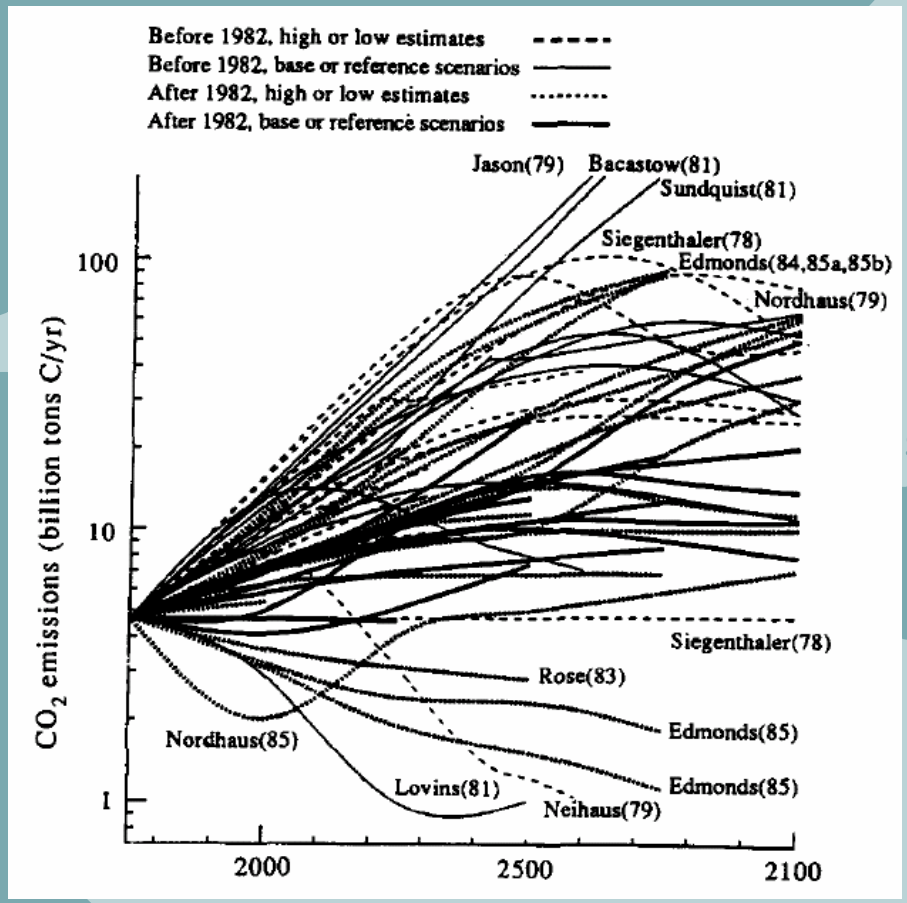

Fig. 4 Forecasts of CO_2 emissions from fossil fuels reported before 1985 [Matsuoka et al., 1995].

Sources: Jason, 1979; Bacastow and Keeling, 1981; Sundquist and Plumme, 1981; Siegenthaler and Oeschger, 1978; Edmonds and Reilly, 1985; Edmonds et al., 1984; Nordhaus, 1979; Rose et al., 1983; Niehaus and Williams, 1979; Lovins et

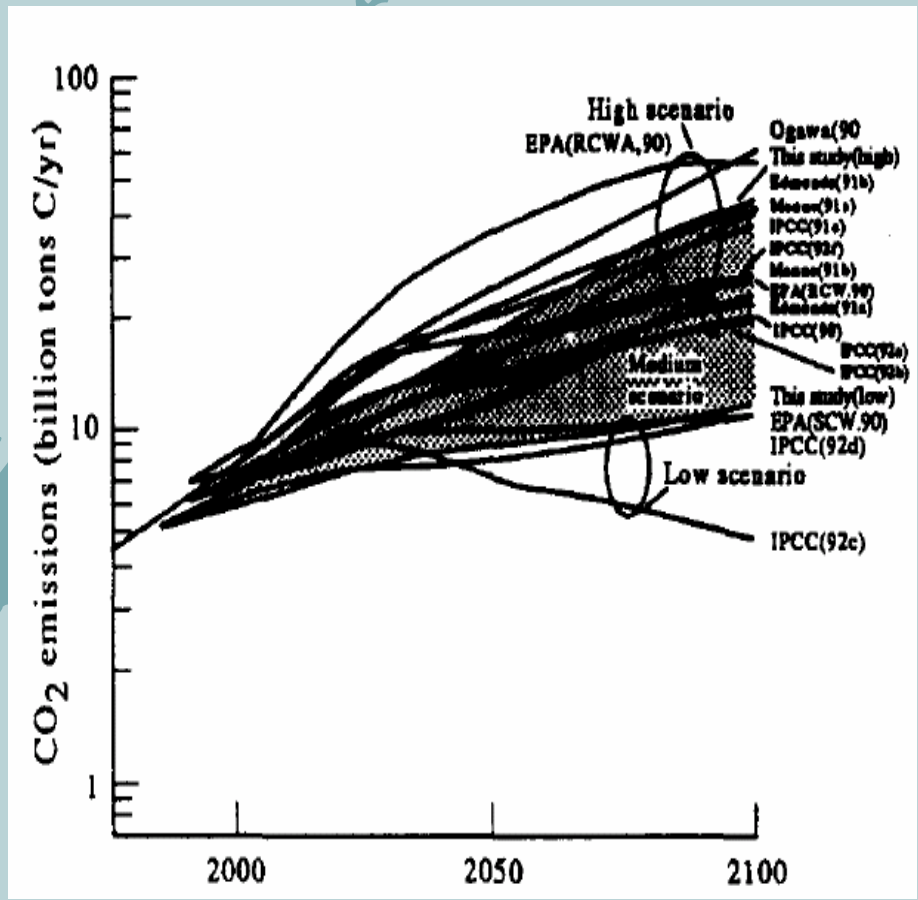

Fig. 5 Recently reported forecasts of CO2 emissions from fossil fuels [Matsuoka et al., 1995]. The shaded area denotes the range of calculations used in this paper.

Source: Lashof and Tirpak, 1990; Ogawa, 1990; Edmonds et al., 1991; Manne and Richels, 1991; Pepper et al., 1992; IPCC, 1990.

3.6 Rages of various assumptions

- Ranges of socioeconomic assumptions
  - Ozone-depleting gases excluding substitute CFCs
  - Land-use transformation
- Ranges of natural environmental assumptions
  - “Missing sink”
  - The fertilization effect of CO_2
  - The release of carbon stored in terrestrial ecosystems
  - The increase in CH_4 emissions
  - The effect of the destabilization of methane hydrates
  - Changes of the functioning of the ocean

4. Simulations using the AIM

4.1 Summary of the models

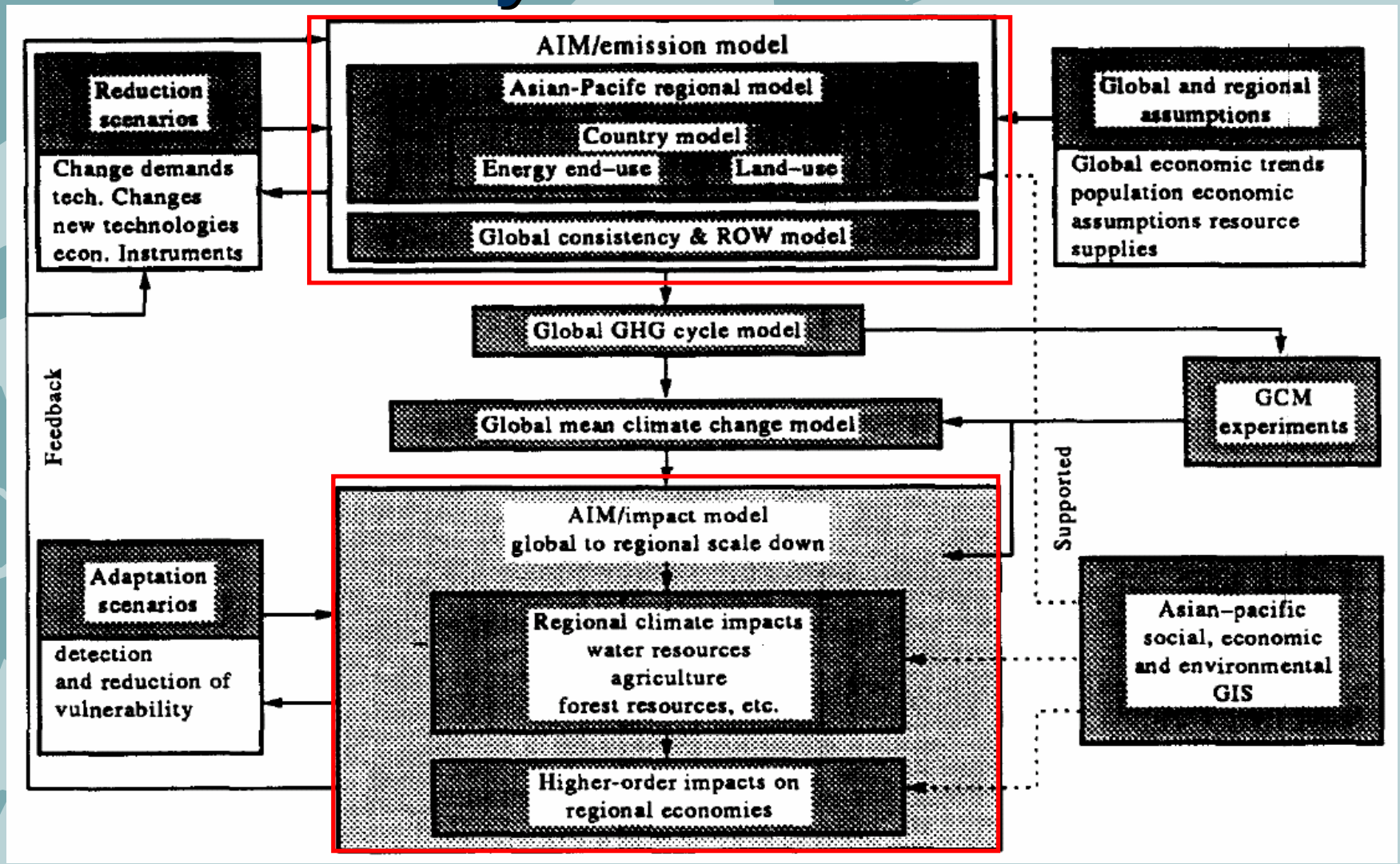

Fig. 6 A summary of the Asian Pacific Integrated Model (AIM) [Matsuoka et al., 1995].

4.2 Simulation cases

- **High standard scenario**: high population (13.5 billion in 2100), high economic growth (IRS91a, growth rate +20%), and low energy efficiency scenario
- **Low standard scenario**: low population (11.3 billion in 2100), low economic growth (IRS91a, growth rate -20%), and high energy efficiency scenario
- **Stabilization scenario**
- **Reduction scenario**

} **The introduction of a carbon tax**

4.3 Results

- AIM/emission model -

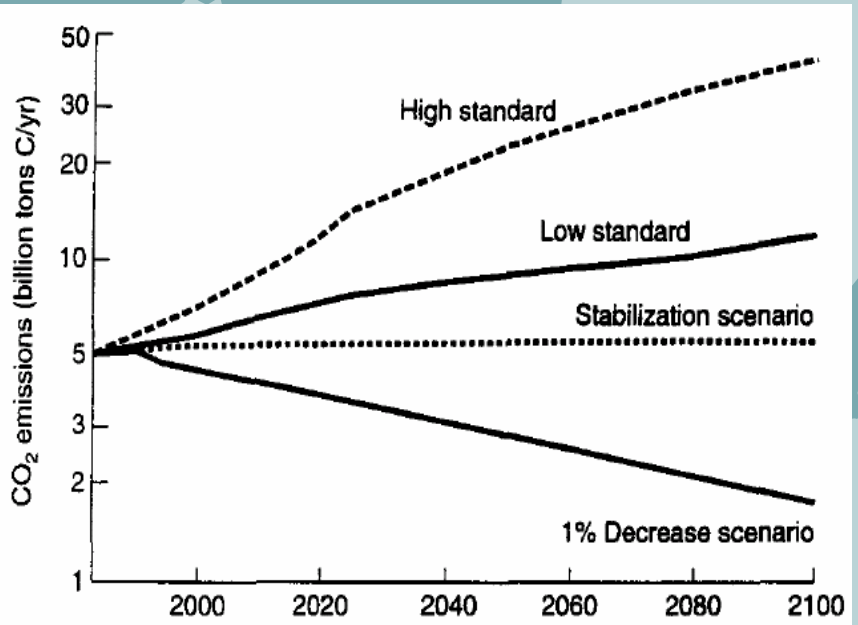

Fig. 7 CO_2 emissions due to fossil fuel combustion [Matsuoka et al., 1995].

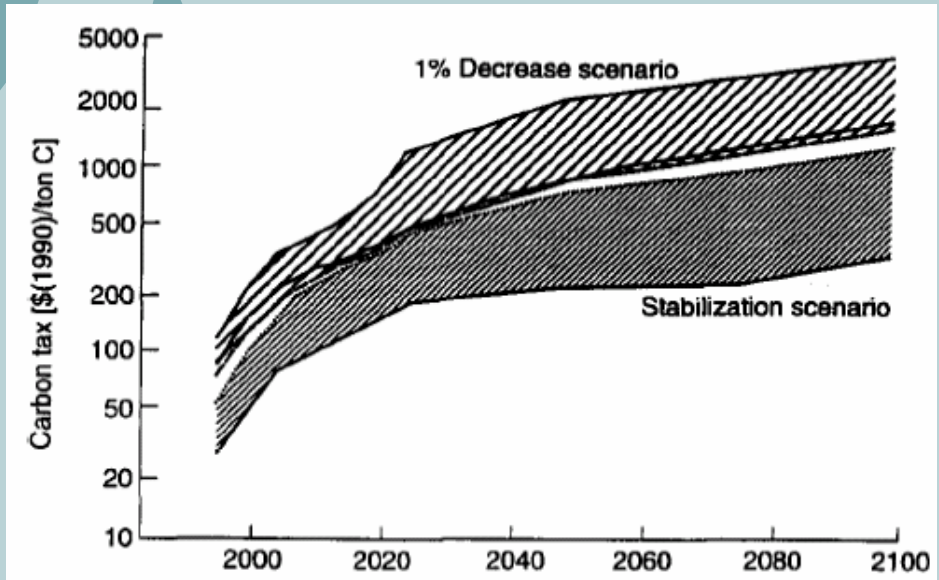

Fig. 8 Changes in carbon tax rates [Matsuoka et al., 1995].

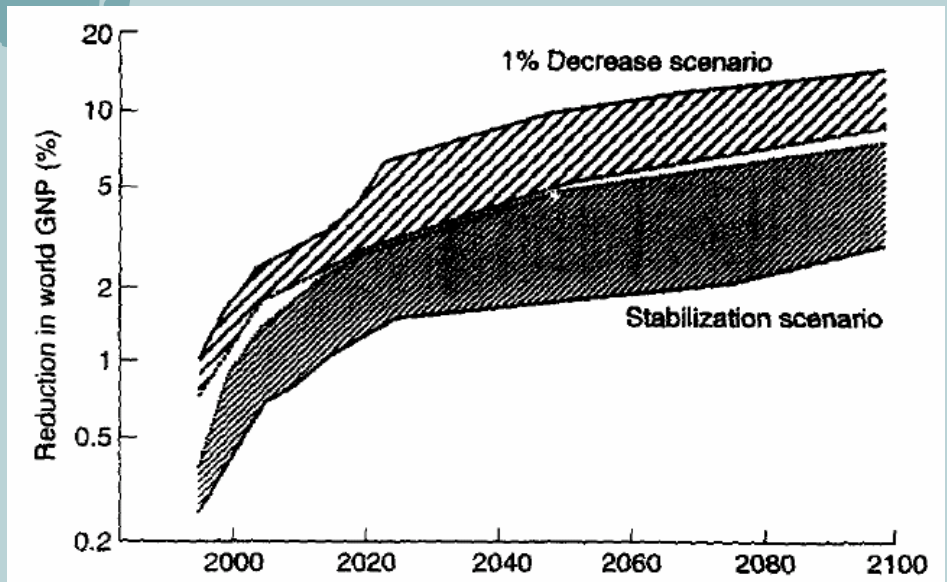

Fig. 9 Reduction in the rates of world GNP [Matsuoka et al., 1995].

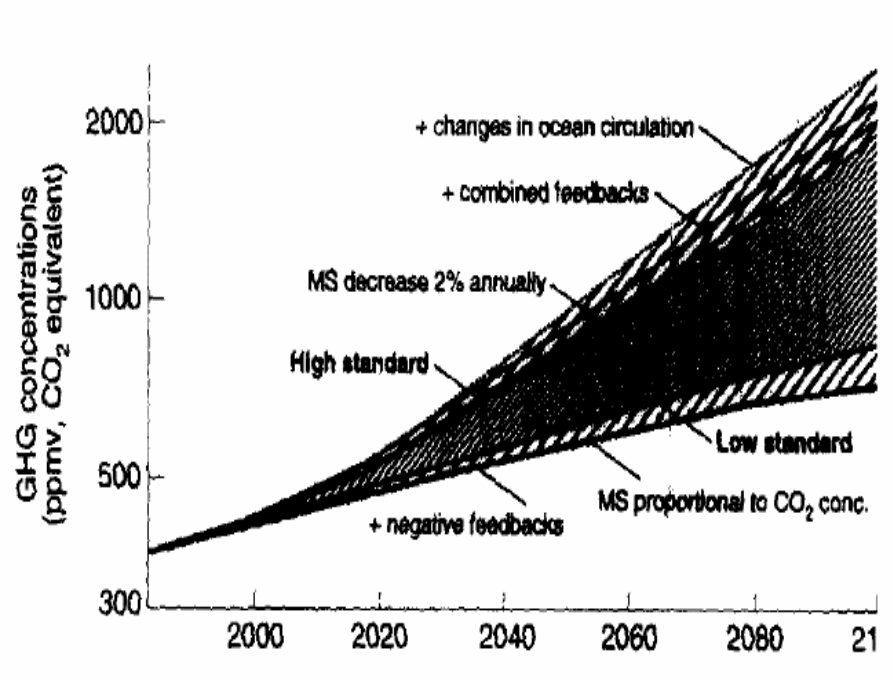

Fig. 10 Changes in greenhouse gas concentrations with a climate sensitivity of 3℃[Matsuoka et al., 1995].

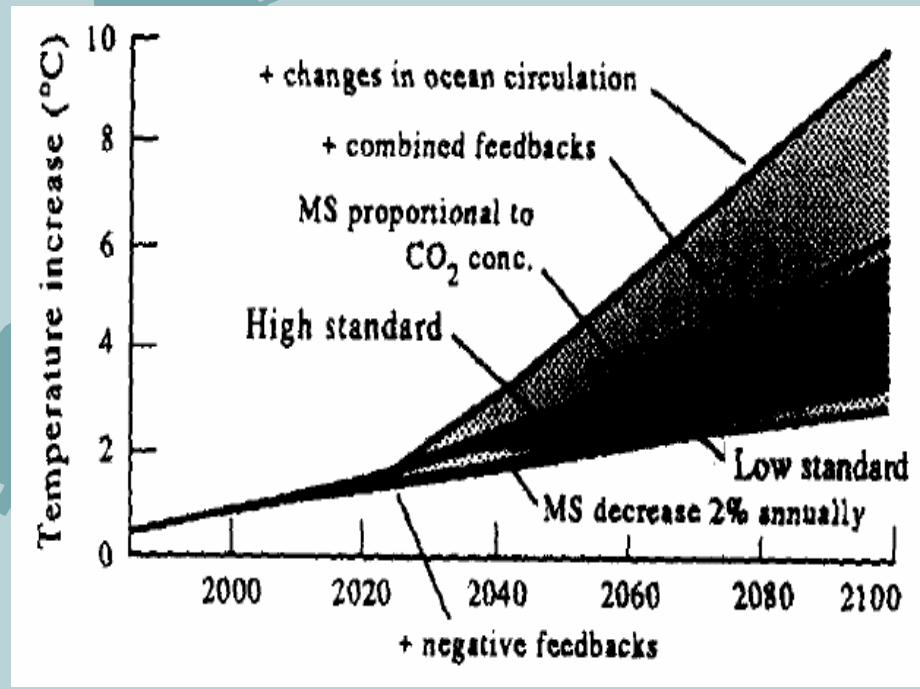

Fig. 11 Temperature increase with a climate sensitivity of 3℃ [Matsuoka et al., 1995].

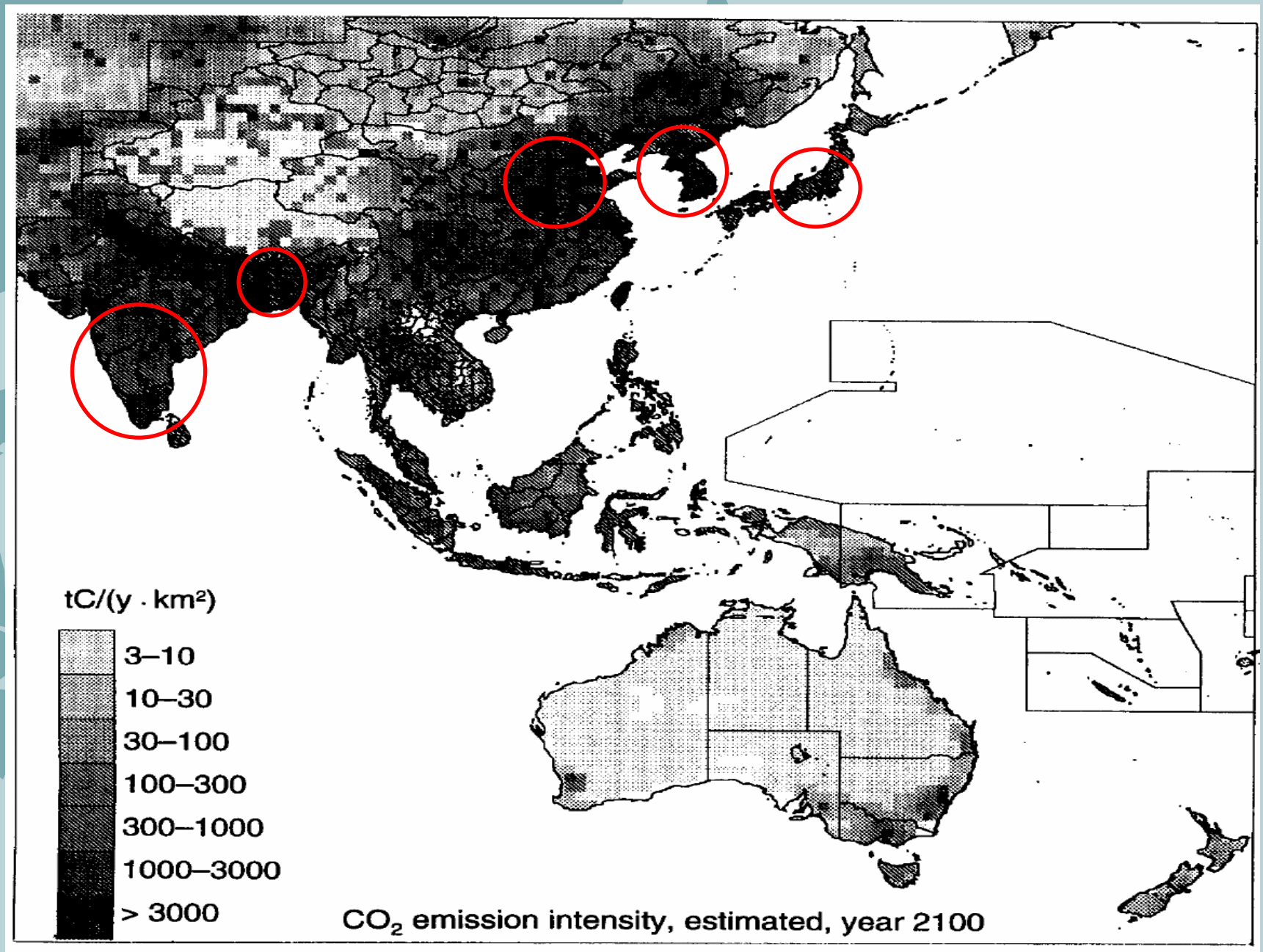

Fig. 12 Estimates of CO_2 emission intensities in the Asian Pacific region in the year 2100 [Matsuoka et al., 1995].

- AIM/impact model -

- AIM/impact model has focused on water resources, vegetation, and agriculture.
  - Global patterns of the temperature increase and changing rates of precipitation from $1\times CO_2$ and $2\times CO_2$ GCM experiments
  - The finer patterns based on observation [Legates and Willmott, 1989]

Interpolation

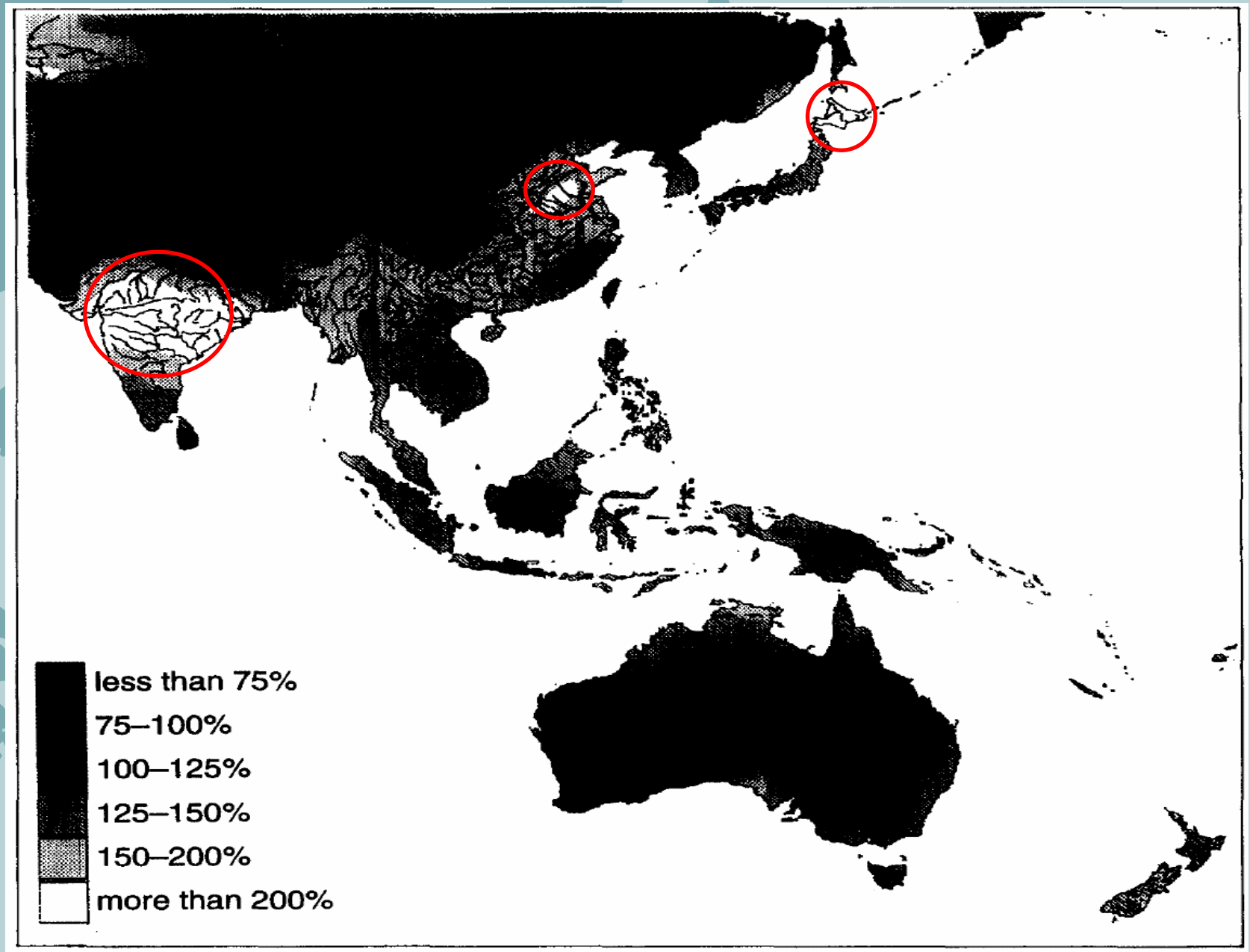

Fig. 13 Predicted ratios of monthly high-flow discharges (percentage of $2\times CO_2$ / $1\times CO_2$) over a 10-year return period [Matsuoka et al., 1995].

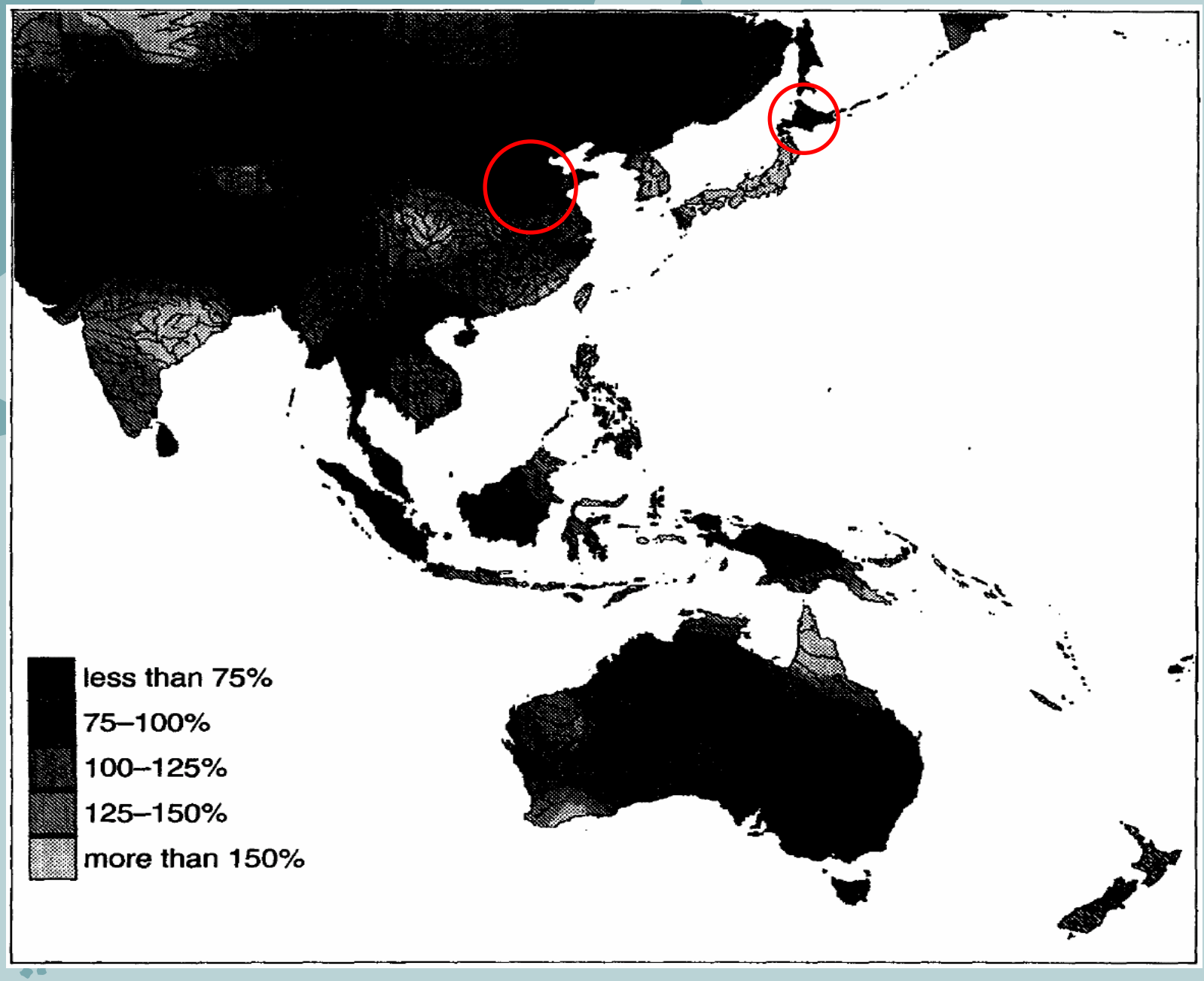

Fig. 14 Predicted ratios of monthly low-flow discharges (percentage of $2\times CO_2$ / $1\times CO_2$) over a 10-year return period [Matsuoka et al., 1995].

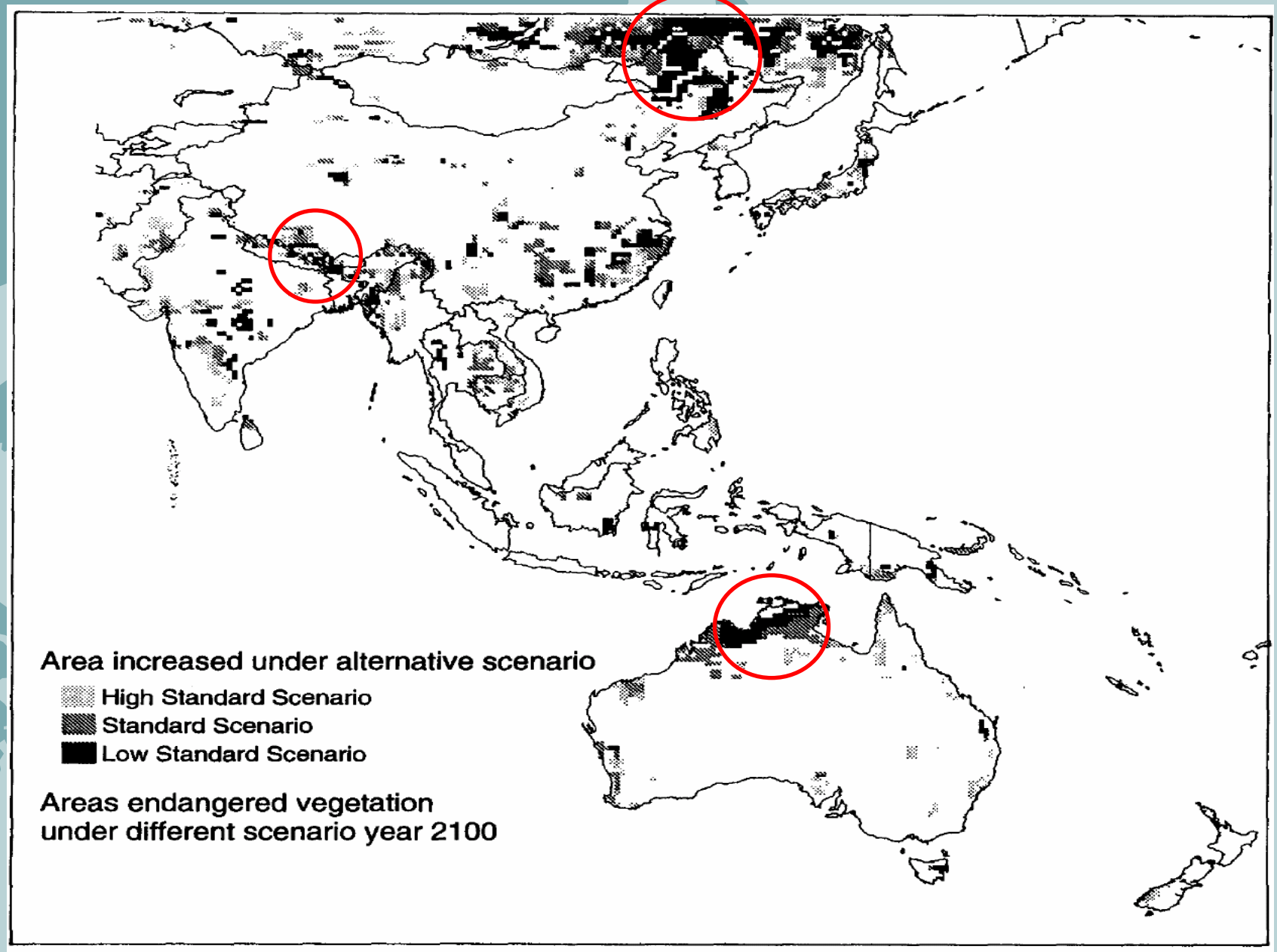

Fig. 15 Potential changes in vegetation under various scenarios in the year 2100 [Matsuoka et al., 1995].