

東京大学教養学部

2011年度夏学期

地球温暖化と経済学

第10-11回 地球温暖化（その1 IPCC報告書）

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はじめに

IPCC（温暖化に関する政府間パネル）とは（1998年6月Robert Watsonの演説）

政治と科学 専門家と各国政府の関わり具合

WMO（世界気象機関）とUNEP（国連環境計画）が共同で1988年に設立した国連の組織

目的「気候変動に関する現状の知識を整理し、政策決定者に伝えること」

2007年に第4次報告書完成 同年ノーベル平和賞受賞

IPCC報告書

WG1 温暖化の科学、WG2 影響・適応・脆弱性、WG3 緩和対策

1、第1次報告書（1990年）

過去100年間 平均気温0.3-0.6℃上昇、海面は10-20cm上昇

特段の対策無し→平均気温は3℃（2℃～5℃）、海面は65cm上昇（30cm～100cm）

現在の濃度での安定化 GHG排出を直ちに60%削減の要→不可能

気候変動枠組み条約採択へ（1992年） 科学と政治

2、第2次報告書（1995年）

気候変動枠組み条約とIPCC 1992年、第2条に関する調査を活動に含める

危険でない濃度、その濃度での安定化の達成期間に関する情報提供 →現在の科学的知見では困難

特段の対策無ければ→2100年までに平均気温が2℃(1.0-3.5℃)上昇、海面上昇は50cm (15-90cm)

中位のシナリオ、エアロゾルの影響で下がる

「色々な証拠から、温暖化は人為的なものであると識別できる」

京都議定書合意へ

3、排出シナリオ特別報告書（SRES）2000年 （資料1、2）

4つのファミリー（A1、A2、B1、B2）と6つのシナリオグループ（A1F1、A1B、A1T、A2、B1、B2）

- A 1 : ファミリー、高成長、技術革新、地域間格差の縮小を特徴とする社会
- A 2 : 多元的社会で地域の独自性の保持と高い人口増加率を特徴とする社会
- B 1 : 持続可能な社会で地域間格差解消やサービス・情報化を特徴とする社会
- B 2 : 経済、社会、環境面で持続可能性に配慮するために地域的対策を重視する社会
- A 1 F 1 は化石燃料集約型、A 1 T は非化石燃料依存型、A 1 B はこの中間

4、第3次報告書（2001年）

1) 第1作業部会報告書 気候系についての理解の現状と将来の気象予測

20世紀中の温度上昇は 0.6°C ($0.4\text{--}0.8^{\circ}\text{C}$)、

「過去50年間の温暖化の大部分は人為的なものとする新たな且つ強固な証拠がある」

“The balance of evidence suggests a discernible human influence on global climate” (SAR)

“There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities”. (TAR)

平均気温は $1.4\sim 5.8^{\circ}\text{C}$ 上昇 (B1～A1FI)、海面上昇は9-88cm

- 大気中のCO₂濃度を450, 650, 1000 ppm で安定化させるためには、人為起源のCO₂排出量をそれぞれ数十年、約100年、および200年以内に1990年のレベル以下とし、その後も減少させることが必要
- 平均気温は2100年までに $1.4\sim 5.8^{\circ}\text{C}$ 上昇する

→降水量増加、異常気象発生

2) 第2作業部会 第3次報告書の新たな知見を中心に

温暖化と損害に関する知見（資料3） 目標温度との関係

3) 第3作業部会 緩和対策（排出削減及び吸収）日本 21/455名

- ① 温暖化対策以外に他の社会経済政策との統合や将来の発展のあり方を含んだ検討が必要

脱炭素社会に向けて社会経済構造を変えなければならない

- ② 技術の役割の重要性と技術革新・普及政策の重要性

風力発電、ハイブリッドエンジン、燃料電池、エネルギー効率改善、燃料転換など

- ③ 京都議定書達成のコストに見通し、コスト削減の手段有り

先進国間の限界削減費用の相違 単位ドル／t C （1990年価格）

	排出権取引なし	排出権取引あり
日本	331	68
ヨーロッパ	211	
アメリカ	178	

長期的にはシナリオと安定化水準によりコストが決まる

費用と便益は部門間で不均衡（石炭、石油、ガス、鉄鋼等はマイナス、Renewablesはプラス

意志決定問題 今後100年間の最善のコースではなく、近未来の最善のコースが重要

5) 技術の普及と障害 (資料4)

5、IPCC第4次報告書 2007年に完成

1) 横断的テーマ 持続可能な発展、緩和と適応、不確実性 etc.

- 持続可能な発展と気候変動 (対策不足と過度の対策のバランス)

The criterion that relates to enabling economic development to proceed in a sustainable manner is a double-edged sword. Projected anthropogenic climate change appears likely to adversely affect sustainable development, with adverse effects tending to increase with higher levels of climate change and GHG concentrations. Conversely, costly mitigation measures could have adverse effects on economic development. This dilemma facing policymakers results in (a varying degree of) tension that is manifested in the debate over the scale of the interventions and the balance to be adopted between climate policy (mitigation and adaptation) and economic development. AR4WG3 ch.1 p.99

- 緩和と適応

温暖化は不可避 緩和と適応の最適点はあるか (資料5)

- 不確実性 気候感度

Climate sensitivity is a key uncertainty for mitigation scenarios for specific temperature levels. P.24

2℃～4.5℃ (best estimate 3℃) (TAR 1.5℃～4.5℃, best estimate 2.5℃)
Weitzman, M., “Reactions to the Nordhaus Critique”, March 2009

2) 温暖化と人為的影響 (WG1 SPM p.10)

Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentration. This is an advance since the TAR’s conclusion that “most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations”.
(very likely>90%)

3) GHG排出増加の要因 (資料6)

1970年－2004年 世界のGHG排出量70%増加

茅恒等式

$$CO_2 = CO_2/energy \times energy/GDP \times GDP/population \times population$$

上記の増分をとると

$$\Delta \text{CO}_2\text{排出量} = \Delta \text{炭素集約度} + \Delta \text{エネルギー効率} + \Delta \text{一人あたり所得} + \Delta \text{人口}$$

エネルギー起源CO₂排出量年平均増加率=1.9% (WG3 Chapter 1, p.107-108)

内訳：炭素集約度-0.2%、エネルギー効率-1.2%、一人あたり所得1.8%、人口1.6%

4) 南北問題 (資料7)

先進国 (2004)：人口20%、GDP(ppp) 57%、GHG排出量46% WG3 SPM p.3

但し、今後は

CO₂ emissions between 2000 and 2030 from energy use are projected to grow 40 to 110% over that period. Two thirds to three quarters of this increase in energy CO₂ emissions is projected to come from non-Annex I regions, with their average per capita energy CO₂ emissions being projected to remain substantially lower (2.8-5.1 tCO₂/cap) than those in Annex I regions (9.6-15.1 tCO₂/cap) by 2030.

5) 安定化濃度と削減率・コスト等

IPCC 安定化濃度に向けての6つのカテゴリー

CO ₂ 濃度 (ppm)	GHG濃度 (ppm)	気温上昇幅 (工業化後、℃)	CO ₂ 排出 ピーク年	CO ₂ 削減率 2050/2000(%)	削減コスト 対GDP(%)	損害	シナリオ数
350-400	445-490	2.0-2.4	2000-2015	-85~-50	5.5未満		6
400-440	490-535	2.4-2.8	2000-2020	-60~-30			18
440-485	535-590	2.8-3.2	2010-2030	-30~+5	1.3(-0~4)		21
485-570	590-710	3.2-4.0	2020-2060	+10~+60	0.5(-1~2)		118
570-660	710-855	4.0-4.9	2050-2080	+25~+85	—	GDPの1~5%	9
660-790	855-1130	4.9-6.1	2060-2090	+90~+140	—		5

IPCC AR4 WG2 SPM P.20 及び WG3 SMP Table 5 及び 6 から作成

上記濃度での安定化に向けての排出経路と気温 (資料8)

先進国90年比25-40%削減とIPCC (資料9)

Bali Action Plan前文 (2007年12月) UNFCCC

Recognizing that deep cuts in global emissions will be required to achieve the ultimate objective of the Convention and emphasizing the urgency¹ to address climate change as indicated in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,

Bali KP AWG (2007年12月)

The AWG recognized that the contribution of Working Group III to the AR4 indicates that achieving the lowest stabilization level assessed by the IPCC to date and its corresponding potential damage limitation would require Annex I Parties as a group to reduce emissions in a range of 25-40 per cent below 1990 levels by 2020.

¹ Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Technical Summary, pages 39 and 90, and Chapter 13, page 776. (資料9のこと)

6) 政策・措置 (資料10)

国際共通炭素税が後退し、セクター別アプローチが前面に

終わりに

IPCC報告 (客観的・科学的情報) と政策決定

IPCCの政治利用に要注意 <http://www.m-yamaguchi.jp/IPCC/IPCC.pdf>

既に始まっている第5次報告の準備 (2013~2014年にかけて完成) (資料11)

IPCC報告書の信頼性

Climategate事件等 日経BPおよび日経エコロミーWebsite 山口光恒、江守正多参照

温暖化から持続可能な発展へ (Millennium Development Goalsとの関係)

貧困・飢餓、普遍的初等教育、女性の地位向上、幼児死亡率低減、妊婦の健康改善、エイズ・マラリア等

環境の持続可能性確保、開発のためのグローバルパートナーシップ推進

(資料1) 排出シナリオの前提

ファミリー		A1			A2	B1	B2
シナリオ	1990	A1F1	A1B	A1T	A2	B1	B2
人口 (十億)	5.3						
2020		7.6	7.5	7.6	8.2	7.6	7.6
2050		8.7	8.7	8.7	11.3	8.7	9.3
2100		7.1	7.1	7.0	15.1	7.0	10.4
世界のGDP (兆ドル)	21						
2020		53	56	57	41	53	51
2050		164	181	187	82	136	110
2100		525	529	550	243	328	235
一人当たり収入比 (発展途上国(非附属書 I国)に対する先進国 及び経済移行国(附属 書I国の比))	16.1						
2020		7.5	6.4	6.2	9.4	8.4	7.7
2050		2.8	2.8	2.8	6.6	3.6	4.0
2100		1.5	1.6	1.6	4.2	1.8	3.0

出典 IPCC SRES p.13

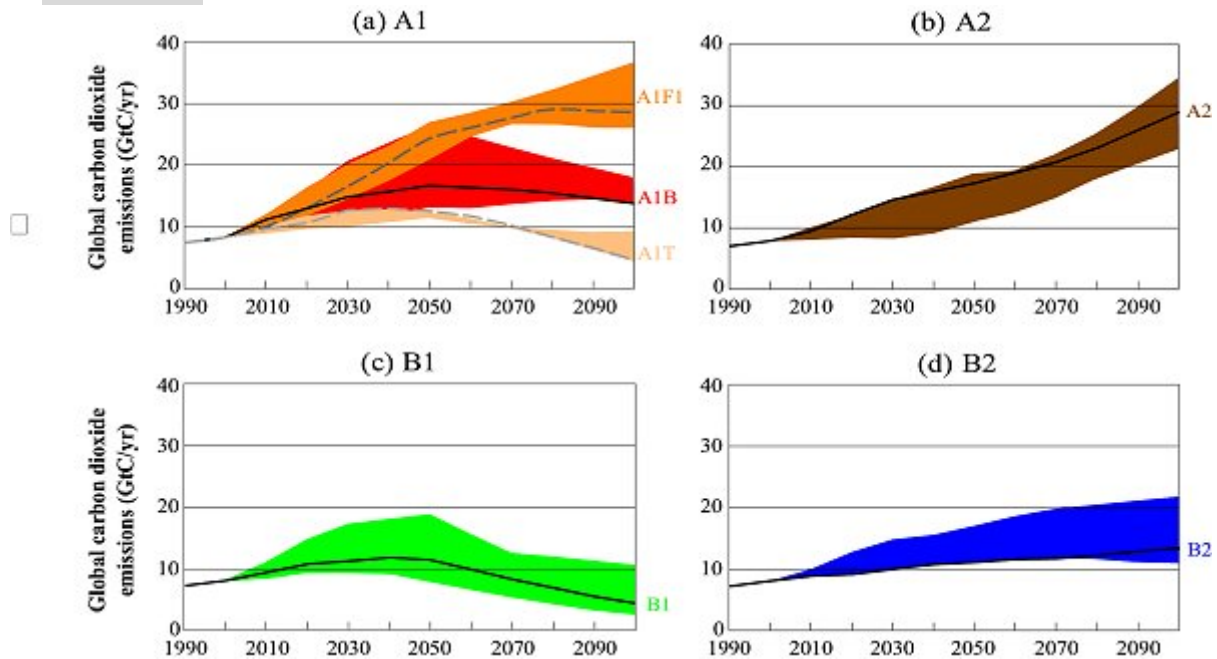
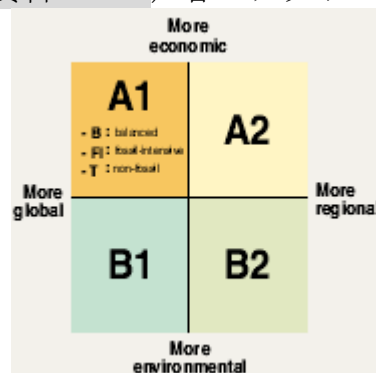
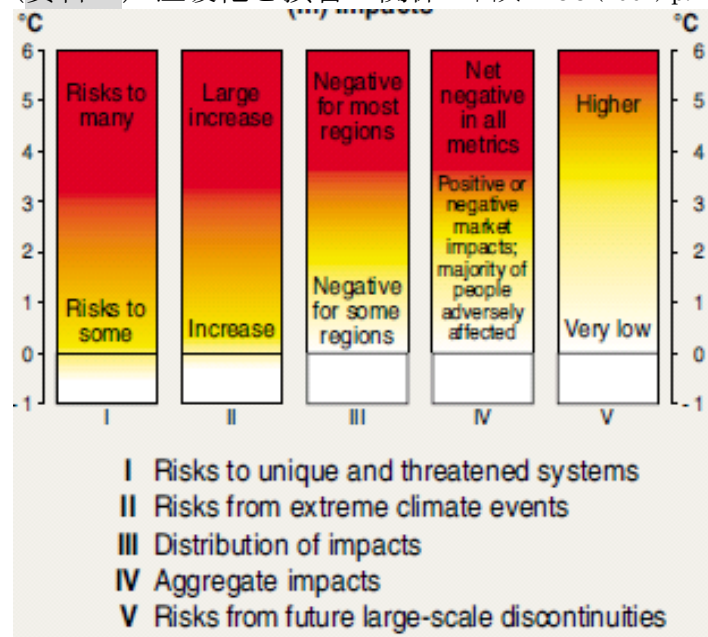
(資料2-1) CO₂排出予測 (4つのファミリーと6つのシナリオ) SRESより

Figure SPM-3: Total global annual CO₂ emissions from all sources (energy, industry, and land-use change) from 1990 to 2100 (in gigatonnes of carbon (GtC/yr) for the families and six scenario groups. The 40 SRES scenarios are presented by the four families (A1, A2, B1, and B2) and six scenario groups: the fossil-intensive A1FI (comprising the high-coal and high-oil-and-gas scenarios), the predominantly non-fossil fuel A1T, the balanced A1B in Figure SPM-3a; A2 in Figure SPM-3b; B1 in Figure SPM-3c, and B2 in Figure SPM-3d. Each colored emission band shows the range of harmonized and non-harmonized scenarios within each group. For each of the six scenario groups an illustrative scenario is provided, including the four illustrative marker scenarios (A1, A2, B1, B2, solid lines) and two illustrative scenarios for A1FI and A1T (dashed lines).

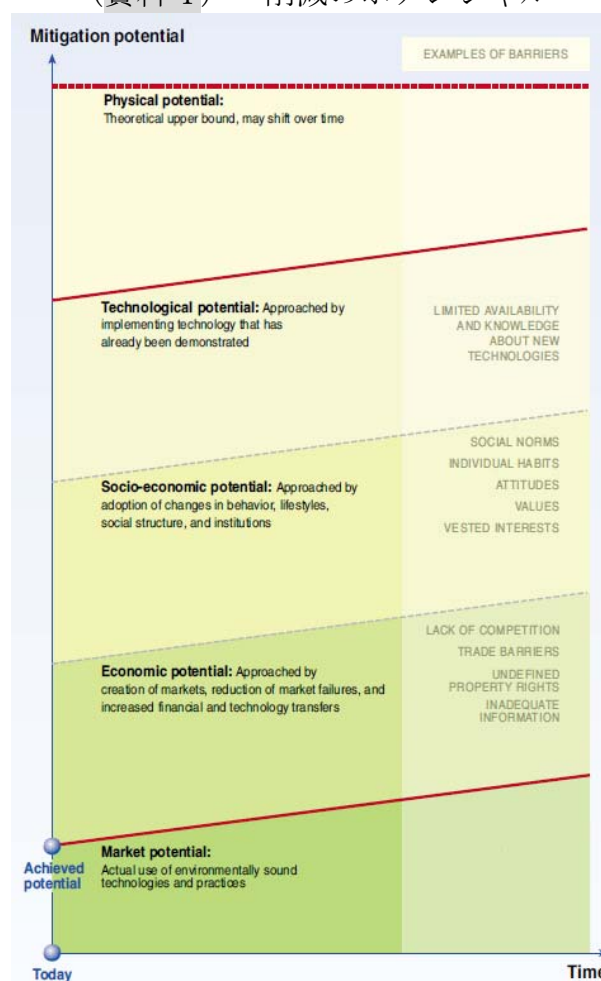
(資料2-2) 各シナリオの意味



(資料3) 温暖化と損害の関係 出典 IPCC (2001) p.11



(資料4) 削減のポテンシャル



出典: “Climate Change 2001 Synthesis Report, Contribution of Working Group 1, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change”, Cambridge University Press

(資料 9)

Box 13.7 The range of the difference between emissions in 1990 and emission allowances in 2020/2050 for various GHG concentration levels for Annex I and non-Annex I countries as a group^a

Scenario category	Region	2020	2050
A-450 ppm CO ₂ -eq ^b	Annex I	-25% to -40%	-80% to -95%
	Non-Annex I	Substantial deviation from baseline in Latin America, Middle East, East Asia and Centrally-Planned Asia	Substantial deviation from baseline in all regions
B-550 ppm CO ₂ -eq	Annex I	-10% to -30%	-40% to -90%
	Non-Annex I	Deviation from baseline in Latin America and Middle East, East Asia	Deviation from baseline in most regions, especially in Latin America and Middle East
C-650 ppm CO ₂ -eq	Annex I	0% to -25%	-30% to -80%
	Non-Annex I	Baseline	Deviation from baseline in Latin America and Middle East, East Asia

Notes:

^a The aggregate range is based on multiple approaches to apportion emissions between regions (contraction and convergence, multistage, Triptych and intensity targets, among others). Each approach makes different assumptions about the pathway, specific national efforts and other variables. Additional extreme cases – in which Annex I undertakes all reductions, or non-Annex I undertakes all reductions – are not included. The ranges presented here do not imply political feasibility, nor do the results reflect cost variances.

^b Only the studies aiming at stabilization at 450 ppm CO₂-eq assume a (temporary) overshoot of about 50 ppm (See Den Elzen and Meinshausen, 2006).

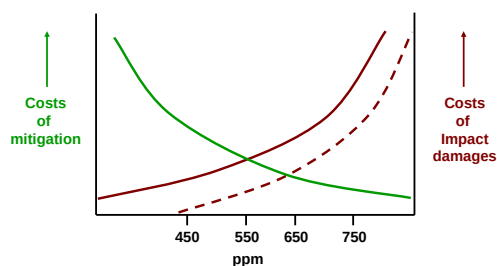
Source: See references listed in first paragraph of Section 13.3.3.3

IPCC AR4, Chapter 13, page 776

(資料 5) Adaptation and Mitigation, Presentation by M. Parry, May 03



Mitigate vs damage, reduced by adaptation



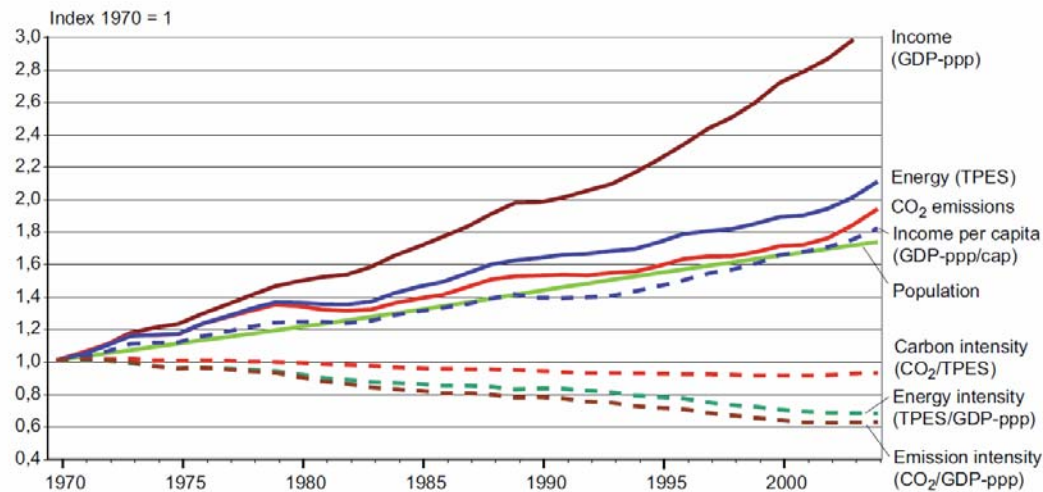
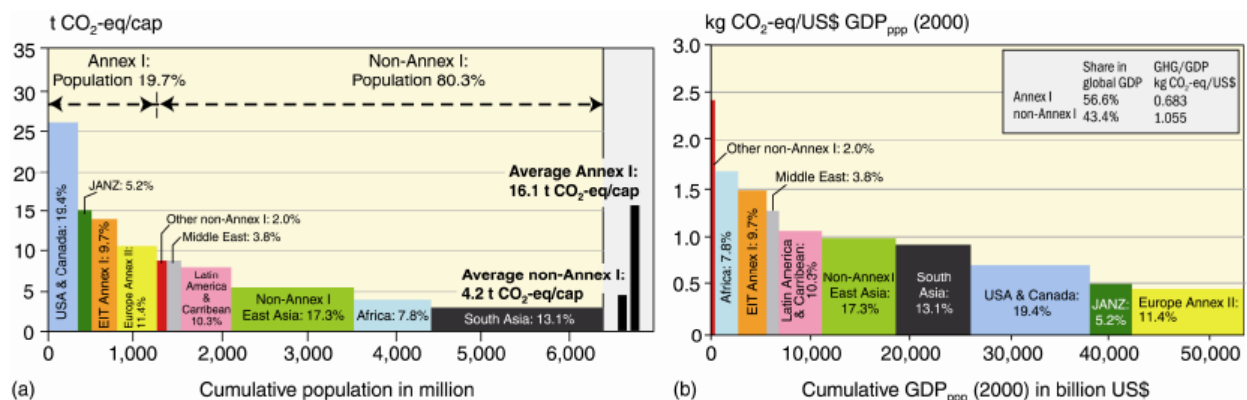
(資料6) エネルギー起源 CO₂ 排出要因分析 1970-2004

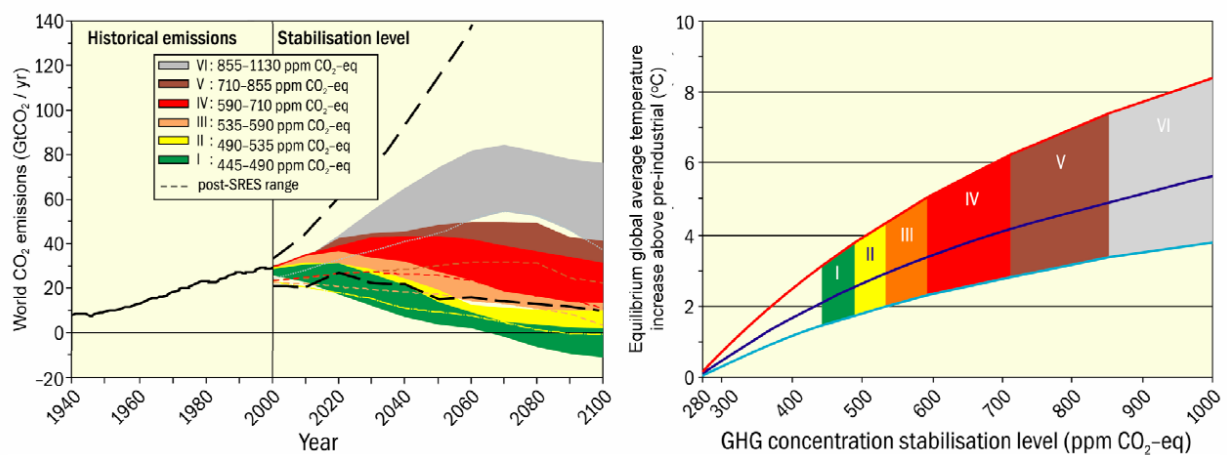
Figure SPM.2: Relative global development of Gross Domestic Product measured in PPP (GDP_{PPP}), Total Primary Energy Supply (TPES), CO_2 emissions (from fossil fuel burning, gas flaring and cement manufacturing) and Population (Pop). In addition, in dotted lines, the figure shows Income per capita (GDP_{PPP}/Pop), Energy Intensity ($TPES/GDP_{PPP}$), Carbon intensity of energy supply ($CO_2/TPES$), and Emission Intensity of the economic production process (CO_2/GDP_{PPP}) for the period 1970-2004. [Figure 1.5]

(資料7) 一人当たり・GDP 当たり GHG 排出量

Regional distribution of GHG emissions by population and by GDP_{PPP}

出典：IPCC AR4 Synthesis Report Topic 2 p.2

(資料8) カテゴリー別排出量と気温上昇幅 出典：IPCC Synthesis Report SPM p.22

CO₂ emissions and equilibrium temperature increases for a range of stabilisation levels

(資料10) 国際的政策・措置

Table 13.3: Assessment of international agreements on climate change.⁴⁵

Approach	Environmental effectiveness	Cost-effectiveness	Meets distributional considerations	Institutional feasibility
National emission targets and international emission trading (including offsets)	Depends on participation and compliance.	Decreases with limited participation and reduced gas and sector coverage.	Depends on initial allocation.	Depends on capacity to prepare inventories and compliance. Defections weaken regime stability.
Sectoral agreements	Not all sectors amenable to such agreements, thereby limiting overall effectiveness. Effectiveness depends on whether agreement is binding or non-binding.	Lack of trading across sectors increases overall costs, although they may be cost-effective within individual sectors. Competitive concerns reduced within each sector.	Depends on participation. Within-sector competitiveness concerns are alleviated if treated equally at global level.	Requires many separate decisions and technical capacity. Each sector may require cross-country institutions to manage agreements.
Coordinated policies and measures	Individual measures can be effective; emission levels may be uncertain; success will be a function of compliance.	Depends on policy design.	Extent of coordination could limit national flexibility, but may increase equity.	Depends on the number of countries (easier among smaller groups of countries than at the global level).
Cooperation on Technology RD&D ^a	Depends on funding, when technologies are developed and policies for diffusion.	Varies with degree of R&D risk. Cooperation reduces individual national risk.	Intellectual property concerns may negate the benefits of cooperation.	Requires many separate decisions. Depends on research capacity and long-term funding.
Development-oriented actions	Depends on national policies and design to create synergies.	Depends on the extent of synergies with other development objectives.	Depends on distributional effects of development policies.	Depends on priority given to sustainable development in national policies and goals of national institutions.
Financial mechanisms	Depends on funding selection criteria.	Depends on country and project type.	Depends on project and country.	Depends on national institutions.
Capacity building	Varies over time and depends on critical mass.	Depends on programme design.	Depends on selection of recipient group.	Depends on country and institutional frameworks.

(資料11) IPCC 5つの代表シナリオ (RCP)

Category	Radiative forcing (W/m ²)	CO ₂ concentration ^{c)} (ppm)	CO ₂ -eq concentrations ^{d)} (ppm)	Global mean temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity ^{b), c)} (°C)	Peaking year for CO ₂ emissions ^{d)}	Change in global CO ₂ emissions in 2050 (% of 2000 emissions) ^{d)}	No. of assessed scenarios
I	2.5-3.0	350-400	445-490	2.0-2.4	2000-2015	-85 to -50	6
II	3.0-3.5	400-440	490-535	2.4-2.8	2000-2020	-60 to -30	18
III	3.5-4.0	440-485	535-590	2.8-3.2	2010-2030	-30 to +5	21
IV	4.0-5.0	485-570	590-710	3.2-4.0	2020-2060	+10 to +60	118
V	5.0-6.0	570-660	710-855	4.0-4.9	2050-2080	+25 to +85	9
VI	6.0-7.5	660-790	855-1130	4.9-6.1	2060-2090	+90 to +140	5
Total							177

RCP3PD(2.6) (Radiative forcing 2.5-3.0 W/m²)
 3.7W/m² : 450 ppm-CO₂ 相当 (シナリオ欠落の認識あり)
 RCP4.5 : 550 ppm-CO₂ 相当
 RCP8.5 (Radiative forcing 6.0-7.5 W/m²)
 RCP6.0 : 650 ppm-CO₂ 相当

図 A-3 濃度と放射強制力、気温上昇の関係 (IPCC AR4 を加工) RITE 秋元主席研究員作成