



Knowledge and data gaps in the IPCC's AR6 reports: insights into climate information and data integration needs

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INTERGOVERNMENTAL PANEL ON climate change

Global Warming of 1.5°C

An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

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Climate Change and Land

An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems

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Climate Change 2021 The Physical Science Basis

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Climate Change 2022 Mitigation of Climate Change

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The Ocean and Cryosphere in a Changing Climate

Special Report of the Intergovernmental Panel on Climate Change



WG I WG II



Climate Change 2023

AR6 SYNTHESIS REPORT

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Climate Change 2022 Impacts, Adaptation and Vulnerability



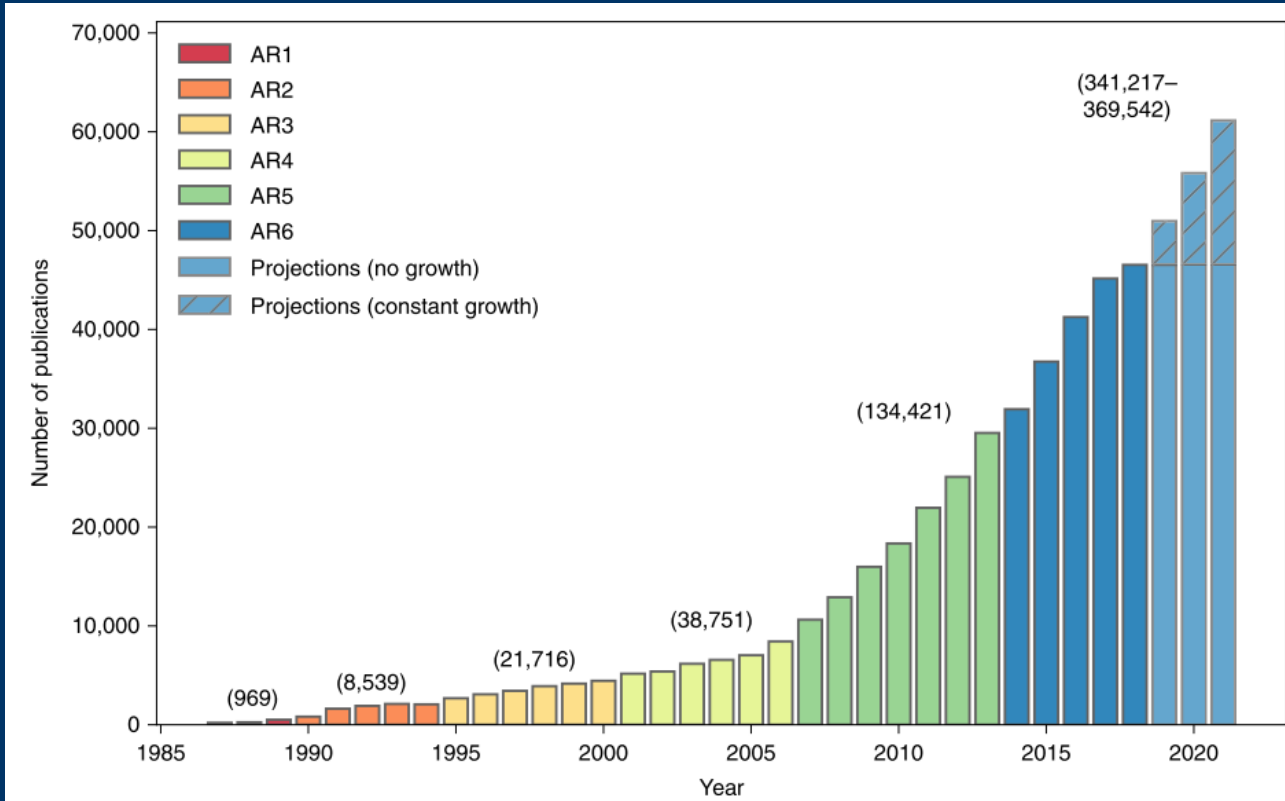
WGII

Working Group II contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change



Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change





Source: Callaghan, M.W., Minx, J.C. and Forster, P.M., 2020. A topography of climate change research. *Nature Climate Change*, 10: 118-123.



Methods: Boolean terms search

Data

data	literature	output
knowledge	observat	parameter
information	model	predict
research	estimate	scien
evidence	analys	understanding
publication	assess	source
papers	gauge	tools
records	instrument	study
metrics	info	studies
report	method	

AND

Gaps

gap	few
limited	minimal
missing	small number
lack	restricted
dearth	modest
shortage	minor
paucity	inadequate
scarc	hamper
spars	constrain
insufficient	restrict
little	negligible



Search Results

- Special Reports 2200
- WGI 2900
- WGII 3000
- WGIII 1800

TOTAL 10 000+

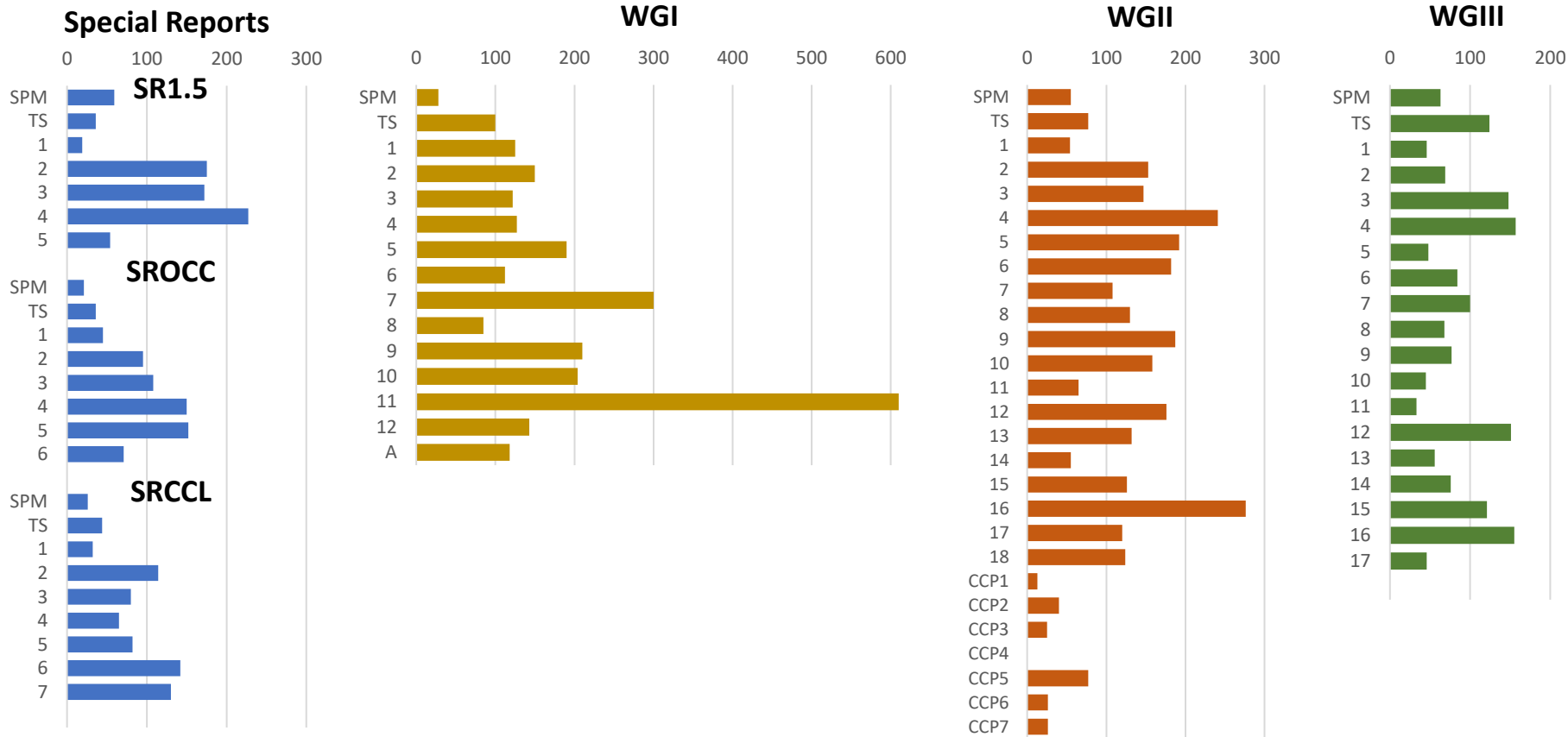


Conservative estimate: e.g. “more research is needed”

Despite the enormous body of knowledge, there is much we still don't know.



Number of search results per chapter





Dedicated “knowledge gaps” sections in chapters

- SRs 13 / 18 chapters
- WGI 8 / 12 chapters
- WGII 9 / 27 chapters and Cross Chapter Papers
- WGIII 14 / 17 chapters

30 chapters did not have dedicated knowledge gaps sections



General data / knowledge gaps

- Availability, access, data sharing, cessation
- Rescue and curation undigitized data
- Scientific research capacity
- Lack of coordination re: common indices and methods

Imbalances in knowledge base

- Academic vs non-academic and 'grey' literature
- English vs non-English literature
- Natural vs social science
- Global North vs Global South
- High vs low-impact journals and the barrier of publication pay-walls.





Spatial / temporal gaps

- Spatial gaps
 - **Geographical** (e.g., Central Africa, Antarctica, Mediterranean)
 - **Typological** (e.g., mountains, islands, shallow ocean, deep ocean)
 - **Data density**, model resolution (especially variable data like precipitation)
 - **Downscaling** - consequences for forecasting climate change and variability for small, topographically diverse areas, like small islands or cities.
- Temporal gaps
 - Historical / pre-historical
 - **Pre-satellite**, pre-instrumental, pre-industrial, past 2000 years, Holocene, paleoclimate
 - **Proxy data**: availability, conversion, loss of natural archives
 - **Indigenous Knowledge and Local Knowledge** to fill gaps, not common
 - **Not emphasised**: Data/knowledge on policy-relevant timescales i.e. decadal and shorter-term projections (e.g. next 5 -10 years) that also include climate variability

Determinants of risk

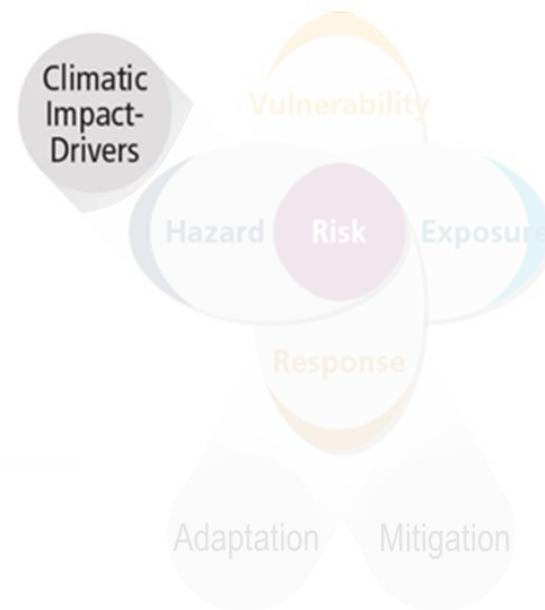
- Risk arising from the interaction of hazard (driven by changes in climatic impact-drivers e.g. means, events, extremes) with vulnerability, exposure and response to climate change





Emissions

- Greenhouse gas fluxes and emissions, aerosols
 - All relevant emissions, not just some
 - In detail and disaggregated by sector, by product, by region
 - Production and consumption based
 - Including embodied emissions with life-cycle analysis
 - Negative emissions (sinks)

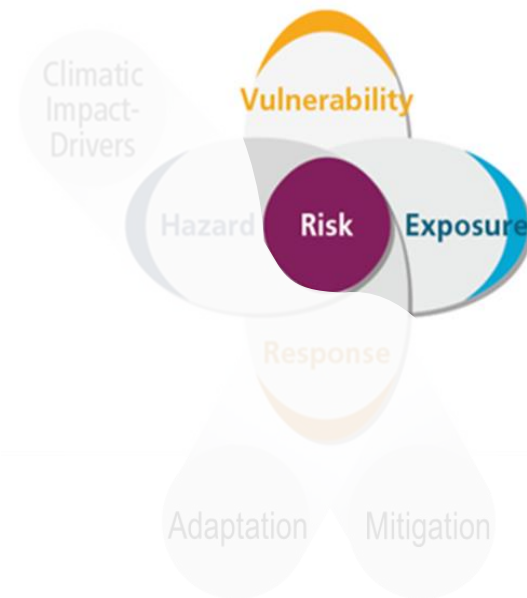


Based on SYR Fig CSB2.1c



Impacts, risks, vulnerability and exposure

- Not many knowledge gaps identified for vulnerability and exposure
- Multiple sectors and systems
 - Natural: Ecosystems, biodiversity, water, range shifts
 - Social: Food systems, health, migration/displacement, poverty
- Losses and damages
- Irreversible impacts and losses
- Certain topics e.g. justice, equity, culture, wellbeing

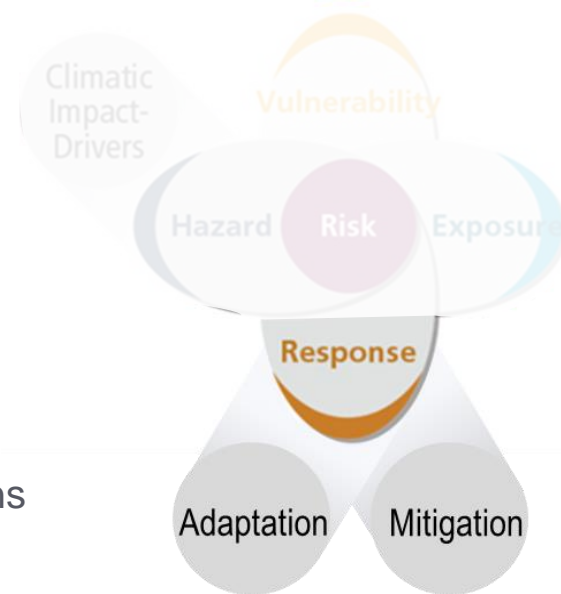


Based on SYR Fig CSB2.1c



Response options – greatest number of knowledge gaps

- Adaptation or mitigation potential, adequacy
- Feasibility, costs, enabling conditions, capacity
- Effectiveness, strengths and weaknesses
- Monitoring and evaluation, metrics, tracking progress
- Climate change impacts on adaptation and mitigation interventions – more or less effective?
- **Transformation**
 - WGII: system transitions, transformative adaptation, Climate Resilient Development
 - WGIII: deep-decarbonization, net-zero, hard-to-avoid emissions
 - Catalysts of change
 - Examples, case-studies, best practice
- **Enablers**
 - Governance, policies, multilevel decision making (tools), financing and investment



Based on SYR Fig CSB2.1c



Climate Models: climate science (WGI)

- **Gases, aerosols, air chemistry**
 - N₂O, hydrofluorocarbons (HFCs), ozone, black carbon, hydroxyl, Non-methane volatile organic compounds (NMOVCs)
- **Water cycle and land surface processes**
 - Large scale circulation, teleconnections, precipitation, African monsoon
 - Plant physiological changes, land use change, groundwater, dams and irrigation
- **Ocean and cryosphere**
 - decadal and multi-decadal cycles, currents, ocean chemistry
 - glaciers, ice sheets, Antarctic sea ice

Key gaps: feedbacks

- Permafrost thaw, wetlands, soil and ocean N₂O fluxes in warmer climate, ocean chemistry and biological processes, land carbon storage with multiple drivers
- Carbon sink to source



Climate Models: impacts, adaptation, vulnerability (WGII)

- **Full cost** of climate change
 - Systemic risks, tipping points, indirect and intangible losses, limits to adaptation
- Better reflection of **complexity**:
 - Better incorporation of socioeconomic factors: poverty, vulnerability, demographic changes, development
 - Integrated / compound risks, nexus or systems approaches
 - Accounting for human interventions or policies (e.g., water availability, with and without adaptation – related crops, yields, energy)
- **Comparability** among structural economic modelling methods
- Extent and timing of **residual risks**
- Risks to **ecosystems** esp. marine and coastal; biodiversity, species compositions
- **Scale**: downscaled climate models to forecast risk
- Forecasting the **effectiveness** of Ecosystem based Adaptation and Nature Based Solutions



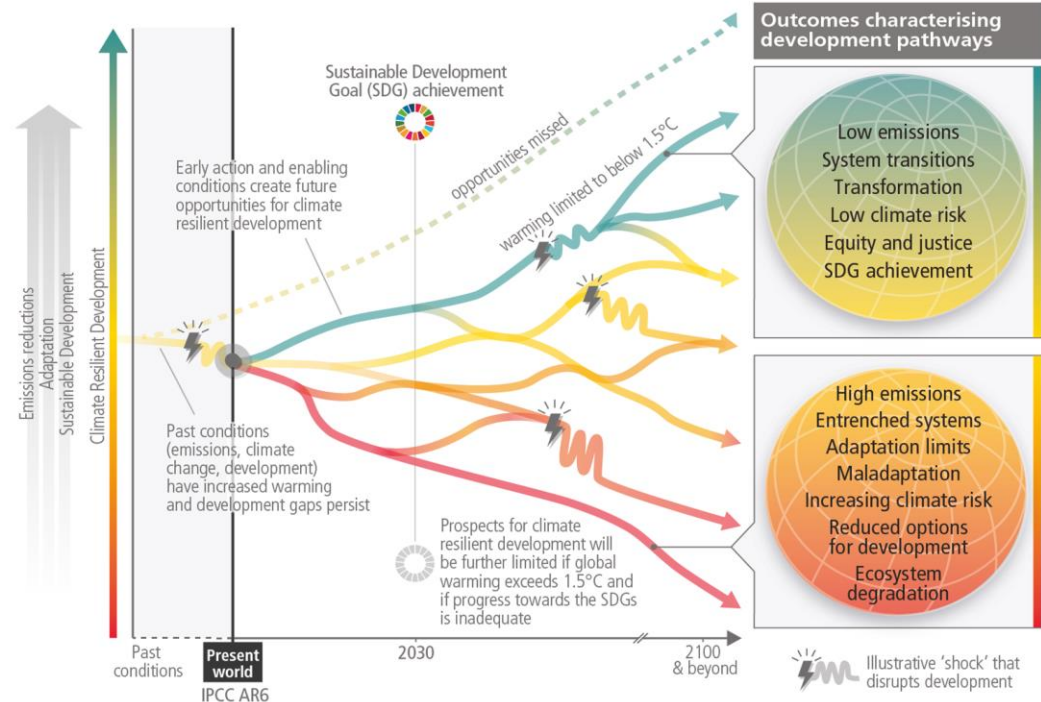
Climate Models: scenarios, pathways (WGIII)

- Modelling of certain components still in its infancy: some **mitigation options** (e.g., demand-side management, full range of Carbon Dioxide Removal, blue carbon)
- **Weakly represented** components (e.g., industry, land use models, innovation)
- **Social aspects** (SDGs, economic activity and/or inequality, welfare)
- **Climate damages** on different sectors, including mitigation actions, avoided impacts
- Impact of **climate policies**
- **Equity**, adaptation, losses and damages, fairness
- Other disturbances **with feedbacks** (e.g. pollution)

Some of the most important data and knowledge gaps are linked to the need for better integration

- All three Working Groups expressed an urgent need for information on complexities and interactions....

Multiple interacting choices and actions can shift development pathways towards sustainability



Key gap: Complex interactions

- **Within or between** the ‘propeller’ components
- **Compound risks** (more than one at a time)
- **Cascading risks** (one thing leading to another)
- **Cross-sectoral** linkages
- **Nexuses** e.g. water-energy-food nexus
- **Feedbacks**



Key gap: Integrated responses

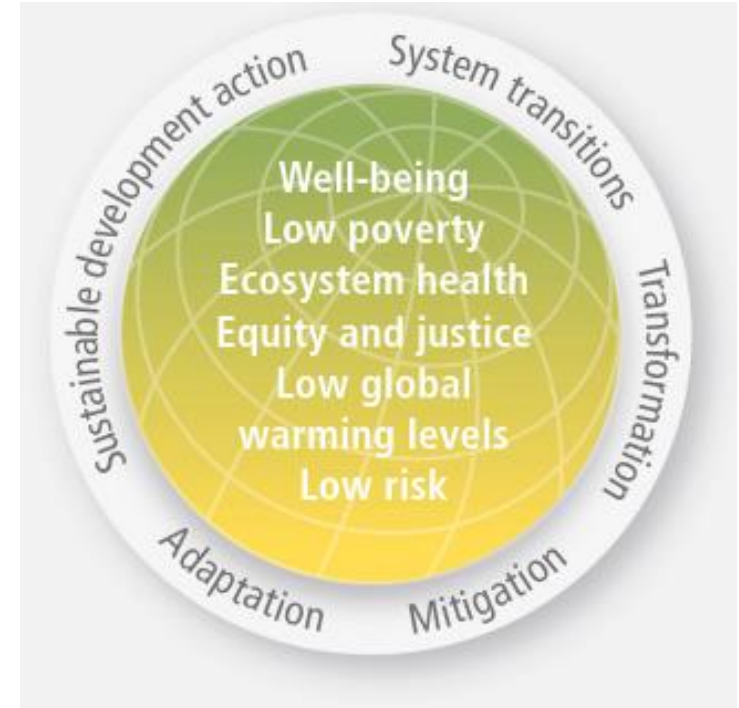
- Responses that address **more than one goal**: mitigation, adaptation, sustainable development (Climate Resilient Development)
- **Sufficiency and de-growth**, reducing inequality, meeting needs
- Co-benefits, **synergies, trade-offs**, negative side-effects
- **Cross-sectoral** approaches
- **Multi-level** decision making
- **Non-siloed research**, systems thinking





Key gap: 'Ideal' or 'best possible' future

- Net-zero, deep mitigation, transformation, Carbon Dioxide Removal
- Systems transitions (natural; built; energy; industry, society)
- Resilience
- Equity and justice
- Economic issues, decoupling
- Emerging technologies
- Case studies, best practice



“What does it look like and how do we get there?”

Extracted from WGII Fig SPM 5

Key gap: Human focus

- Individual emissions, **consumption and demand**, inequality
- Climate change impacts on **human health and wellbeing** and their socio-economic determinants, better metrics of wellbeing
- **Services-focused development**, needs based approaches
- People as **agents of change** (including social organizations)
- Participation in adaptation, mitigation, capacity building, **social networking**, information dissemination, disaster readiness, mobilizing society
- Employment, labour, **'just transition'**, option of shifting labour between sectors



Key gap: Enablers

- **Finance:** economic implications of action versus inaction, adaptation finance, global economic 'teleconnections'
- **Governance:** multilevel, cross-sectoral, international cooperation
- **Technology** development and sharing
- **Capacity development** and sharing, cooperative learning, Indigenous Knowledge and Local Knowledge






Summary

- We need more fundamental basic data, particularly for certain **regions or systems**
- Better models that can handle complexity, and **incorporate many social aspects**
- More literature dealing with **interactions, cross-sectoral impacts**, risks, and responses, systems approaches
- Better **monitoring and evaluation** of responses
- Better **balanced literature** - ensure different knowledges are considered

Reflections from a practitioner



IPCC Co-Chair
Practitioner

EVE....advancing our understanding of the climate system globally, with local granularity

- It is not simply a case of **more climate information, high resolution data**.
- **There are no silver bullets** – climate data are only a part of what drives decision-making.
- **Tool in a bigger toolbox** – a hierarchy of models and a broad range of other tools.
- We need to make sure we are **meeting peoples' needs** – have to ask people what they need at the outset.
- **Resolution vs uncertainty** – be cautious of what is promised.
- Need to look at **the risk profile/unintended consequences** – e.g. the consumption of resources
- **Need action now** – research vs operational needs (e.g. more synthesis work is also important)



We already
know
enough to
act.....

THANK YOU

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