Climate change adaptation and mitigation measures in the EU water environments

Tiina Nõges, Peeter Nõges

Estonian University of Life Sciences

Tartu, ESTONIA

www.emu.ee

Eesti Maaülikool

EMÜ Limnoloogiakeskus

OECD Studies on Water

Water and Climate Change Adaptation

POLICIES TO NAVIGATE UNCHARTED WATERS

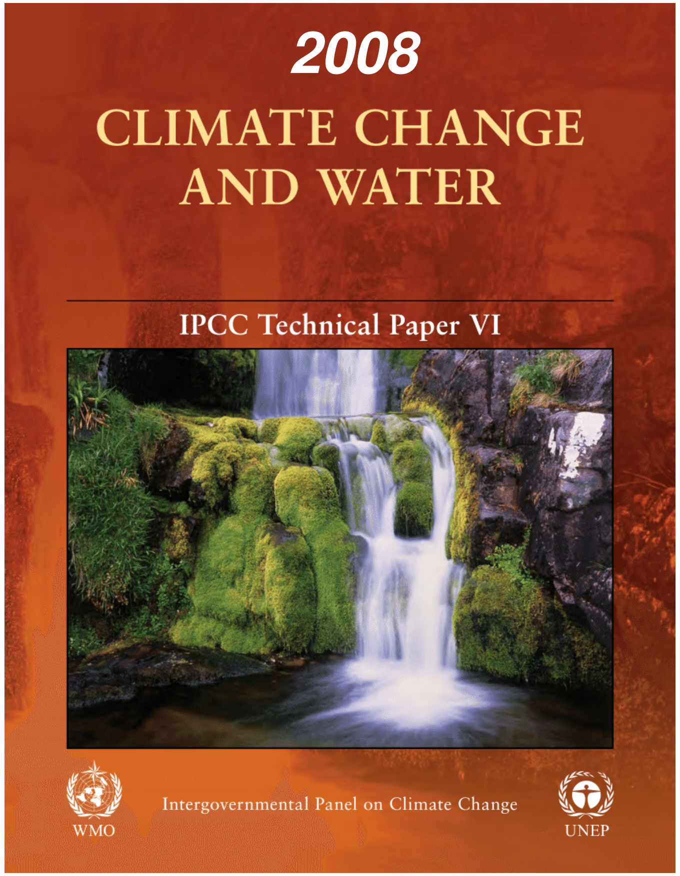
OECD

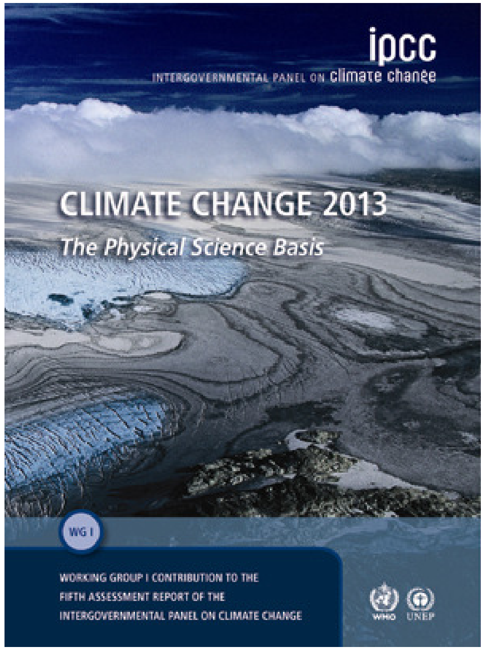
2013

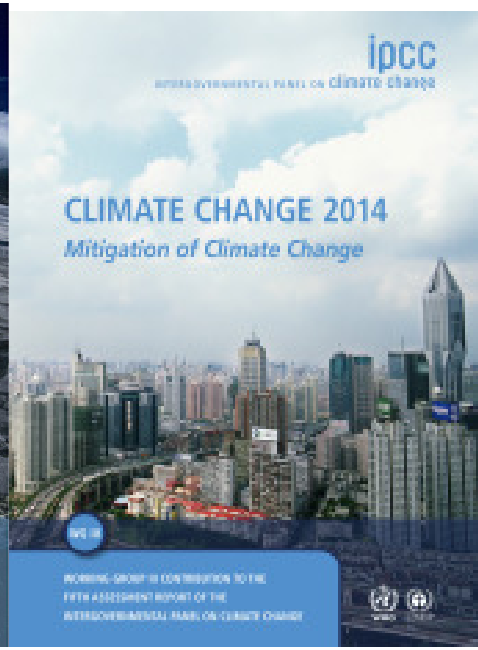
Climate change is, to a large extent, water change

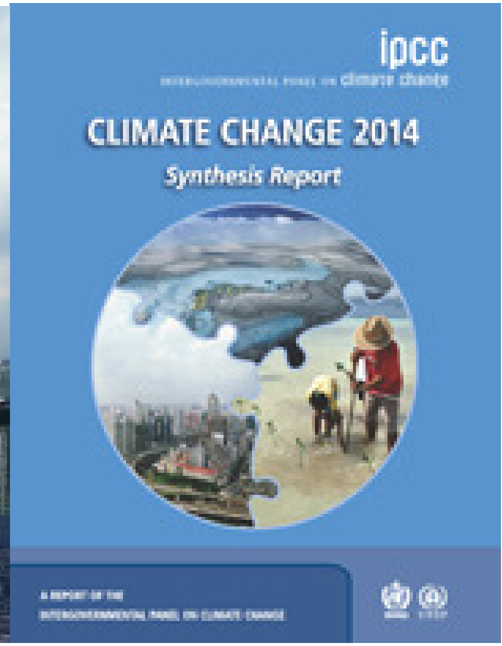
The future for freshwater will not look like the past

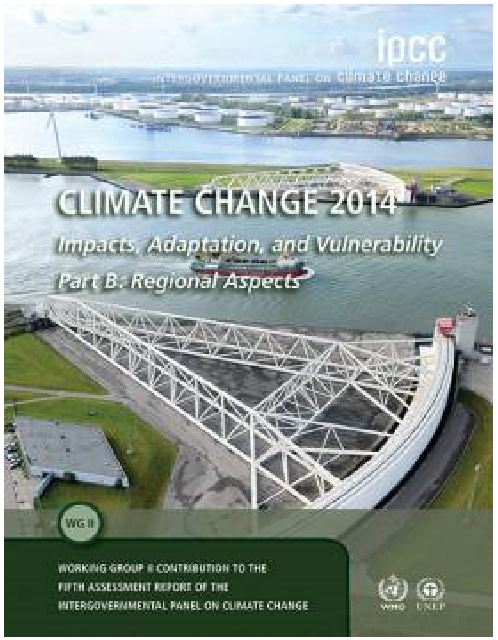
IPCC – Intergovernmental Panel of Climate Change http://www.ipcc.ch/report/ar5/

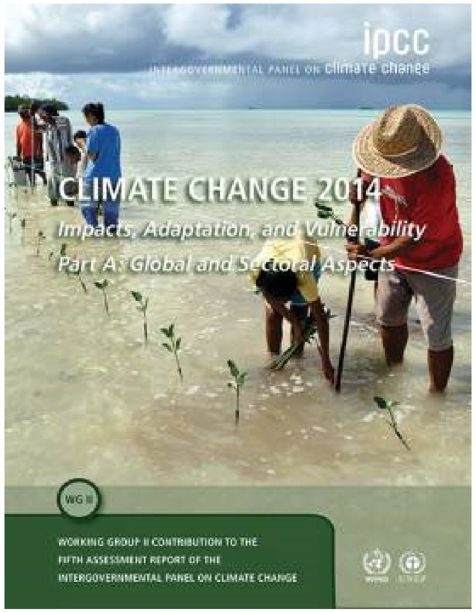












Special Report

Major CC related processes & concerns

Changes in hydrology (river flow, lake levels, retention time, ice regime)

Changed mobility of pollutants in soil and lake sediments

Increased thermal stability of lakes

Shifted timing of meteorological and biological processes

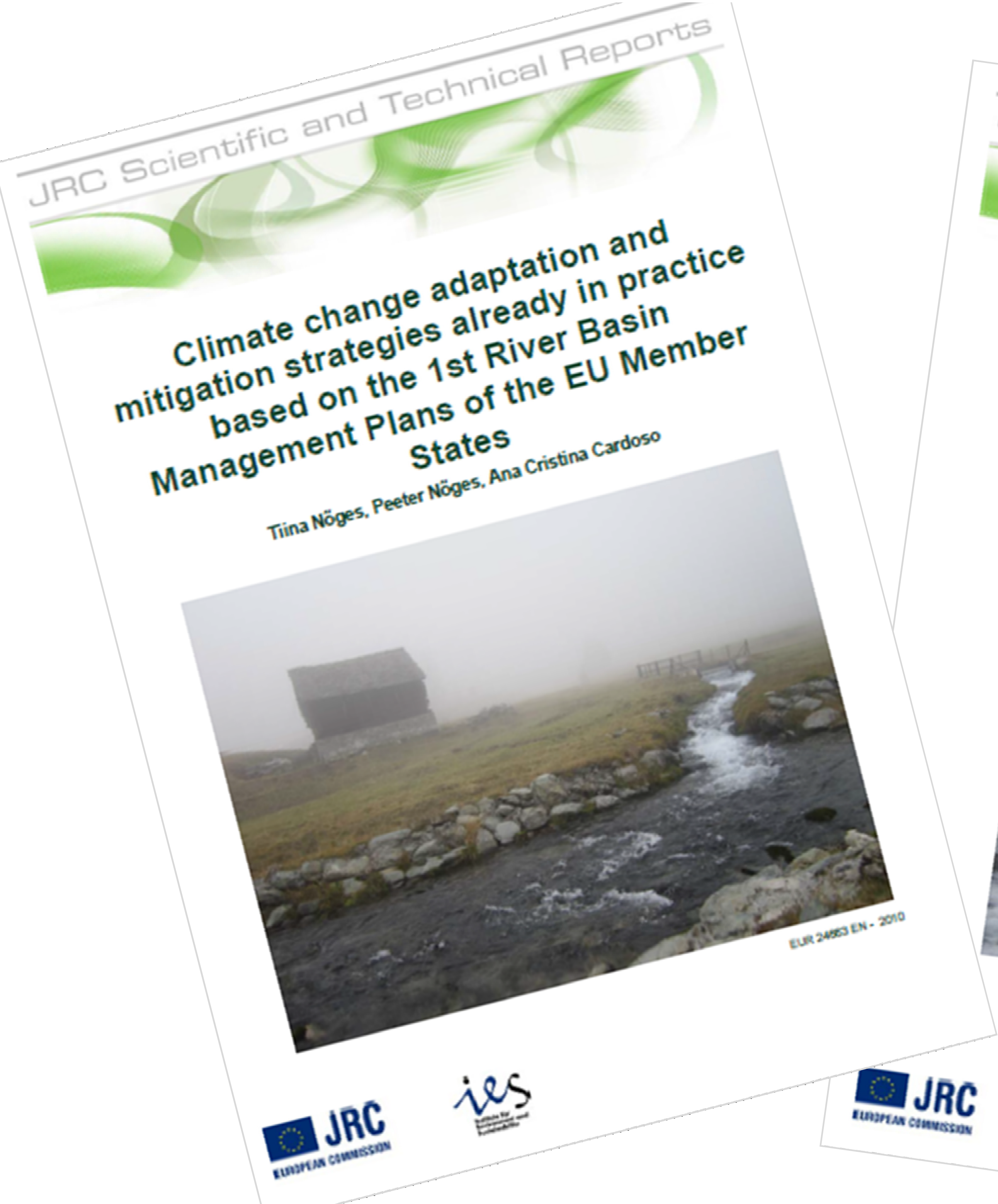
Floods & droughts

Nutrient loads

Natural organic compounds
Hazardous substances

Oxygen depletion

Ecological status (effects on biota)
- Habitat fragmentation
- Habitat shift
- Loss of biodiversity
- Alien species


JRC Scientific and Technical Reports

Climate change adaptation and mitigation strategies already in practice based on the 1st River Basin Management Plans of the EU Member States

Tiina Nõges, Peeter Nõges, Ana Cristina Cardoso

EUR 24653 EN - 2010

JRC
EUROPEAN COMMISSION

ies


JRC Scientific and Technical Reports

Review of published climate change adaptation and mitigation measures related with water

Tiina Nõges, Peeter Nõges, Ana Cristina Cardoso

EUR EN - 2010

JRC
EUROPEAN COMMISSION

ies

RIVER BASIN SCALE WATER MANAGEMENT NEEDED FOR CLIMATE CHANGE MITIGATION & ADAPTATION

- Climate change (CC) mitigation measures aim to reduce greenhouse gas (GHG) emissions
- CC adaptation measures should reduce the vulnerability of societies and ecosystems to adverse effects of CC.
- In respect of water resources and ecological status of water bodies the two approaches are often disconnected that, instead of synergies, can create trade-offs between them

Locatelli, B., 2016. Ecosystem Services and Climate Change.

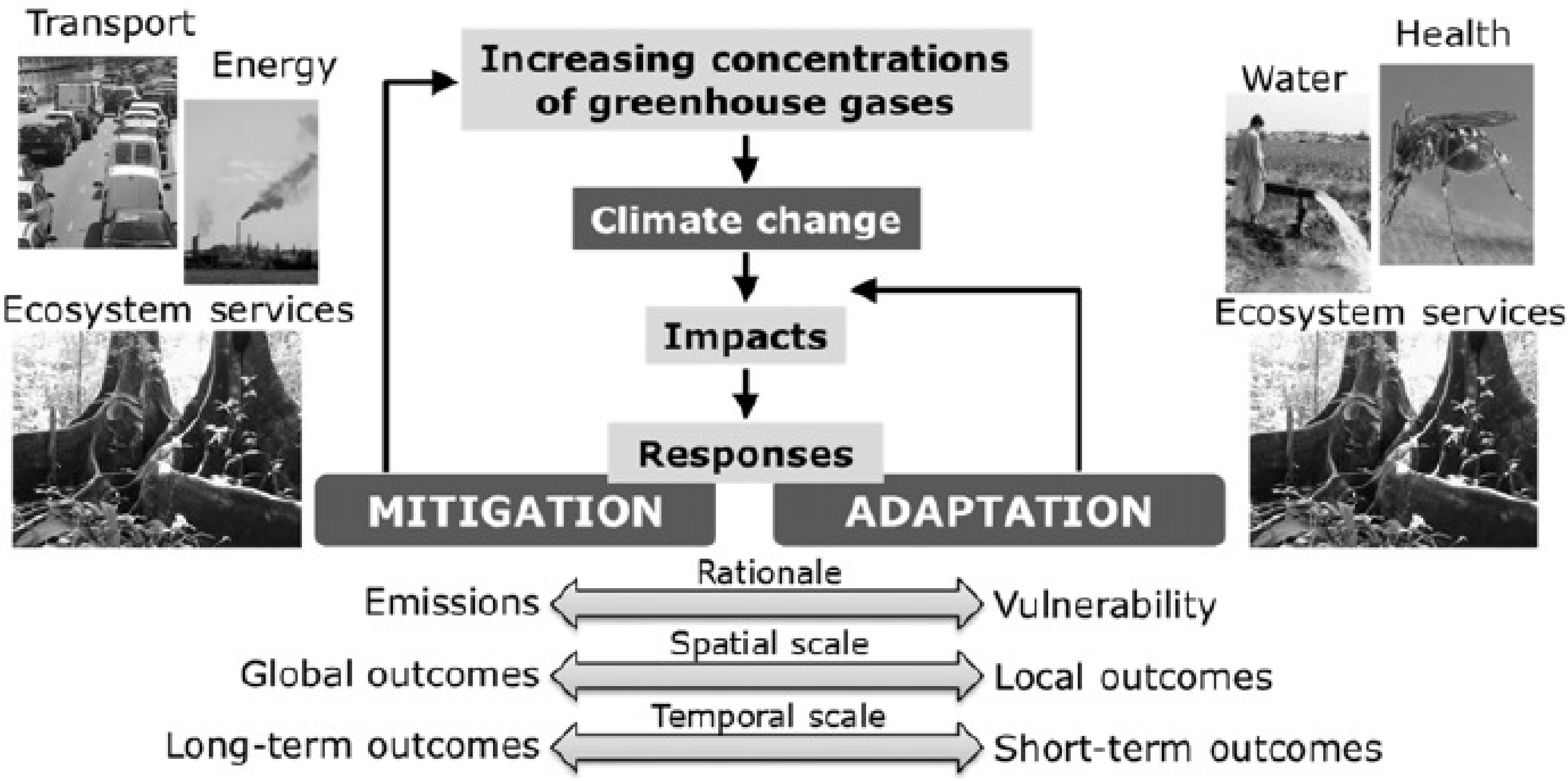
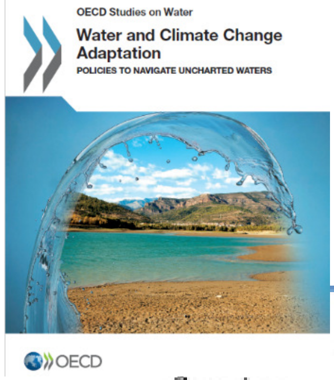


Figure 38.1 Differences between climate change adaptation and mitigation

In: Routledge Handbook of Ecosystem Services. http://hal.cirad.fr/cirad-01264738

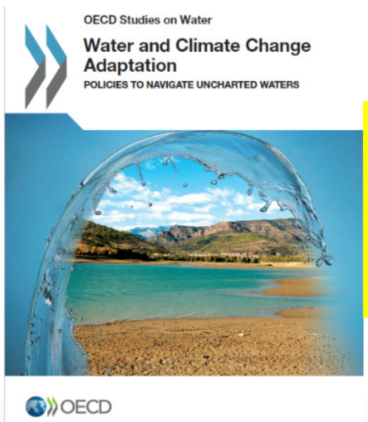


Different concerns even in neighbouring countries

Climate change impacts on water systems

Table 3.1. Primary concerns in OECD countries and the EC

<table>
<tr><th rowspan="2">Country / Area of concern</th><th rowspan="2">Quantity</th><th rowspan="2">Quality</th><th rowspan="2">Water supply & sanitation</th><th colspan="2">Extreme weather events</th><th rowspan="2">Freshwater ecosystrems</th></tr>
<tr><th>Flood</th><th>Drought</th></tr>
<tr><td>Australia</td><td>●</td><td>●</td><td>●</td><td>●</td><td>●</td><td>●</td></tr>
<tr><td>Austria</td><td>●</td><td></td><td>●</td><td></td><td>●</td><td>●</td></tr>
<tr><td>Belgium</td><td>●</td><td>●</td><td>●</td><td>●</td><td>●</td><td>●</td></tr>
<tr><td>Canada</td><td>●</td><td>●</td><td></td><td colspan="2">●</td><td></td></tr>
<tr><td>Chile</td><td>●</td><td>●</td><td>●</td><td>●</td><td>●</td><td>●</td></tr>
<tr><td>Czech Republic</td><td>●</td><td>●</td><td></td><td>●</td><td>●</td><td></td></tr>
<tr><td>Denmark</td><td></td><td></td><td>●</td><td colspan="2">●</td><td></td></tr>
<tr><td>Estonia</td><td>●</td><td>●</td><td>●</td><td>●</td><td></td><td>●</td></tr>
<tr><td>Finland</td><td></td><td></td><td></td><td colspan="2">●</td><td></td></tr>
<tr><td>France</td><td>●</td><td></td><td></td><td></td><td>●</td><td></td></tr>
<tr><td>Germany</td><td>●</td><td></td><td></td><td>●</td><td>●</td><td></td></tr>
<tr><td>Greece</td><td>●</td><td></td><td></td><td></td><td>●</td><td></td></tr>
<tr><td>Hungary</td><td></td><td></td><td></td><td>●</td><td>●</td><td></td></tr>
<tr><td>Iceland</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Ireland</td><td></td><td></td><td>●</td><td></td><td></td><td></td></tr>
<tr><td>Israel</td><td>●</td><td>●</td><td></td><td colspan="2">●</td><td></td></tr>
<tr><td>Italy</td><td>●</td><td></td><td></td><td></td><td>●</td><td>●</td></tr>
<tr><td>Japan</td><td></td><td></td><td></td><td colspan="2">●</td><td></td></tr>
<tr><td>Korea</td><td>●</td><td>●</td><td>●</td><td>●</td><td></td><td>●</td></tr>
<tr><td>Luxembourg</td><td>●</td><td>●</td><td>●</td><td>●</td><td></td><td></td></tr>
<tr><td>Mexico</td><td>●</td><td></td><td>●</td><td>●</td><td>●</td><td>●</td></tr>
</table>



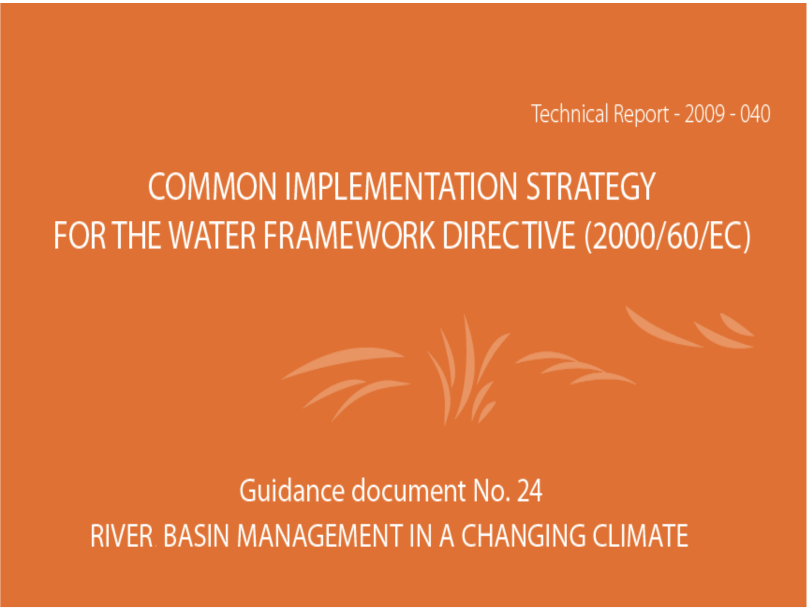
Different Climate Change adaptation plans & strategies even in neighbouring countries

Timeline of development of National Adaptation Strategies and Plans in OECD countries

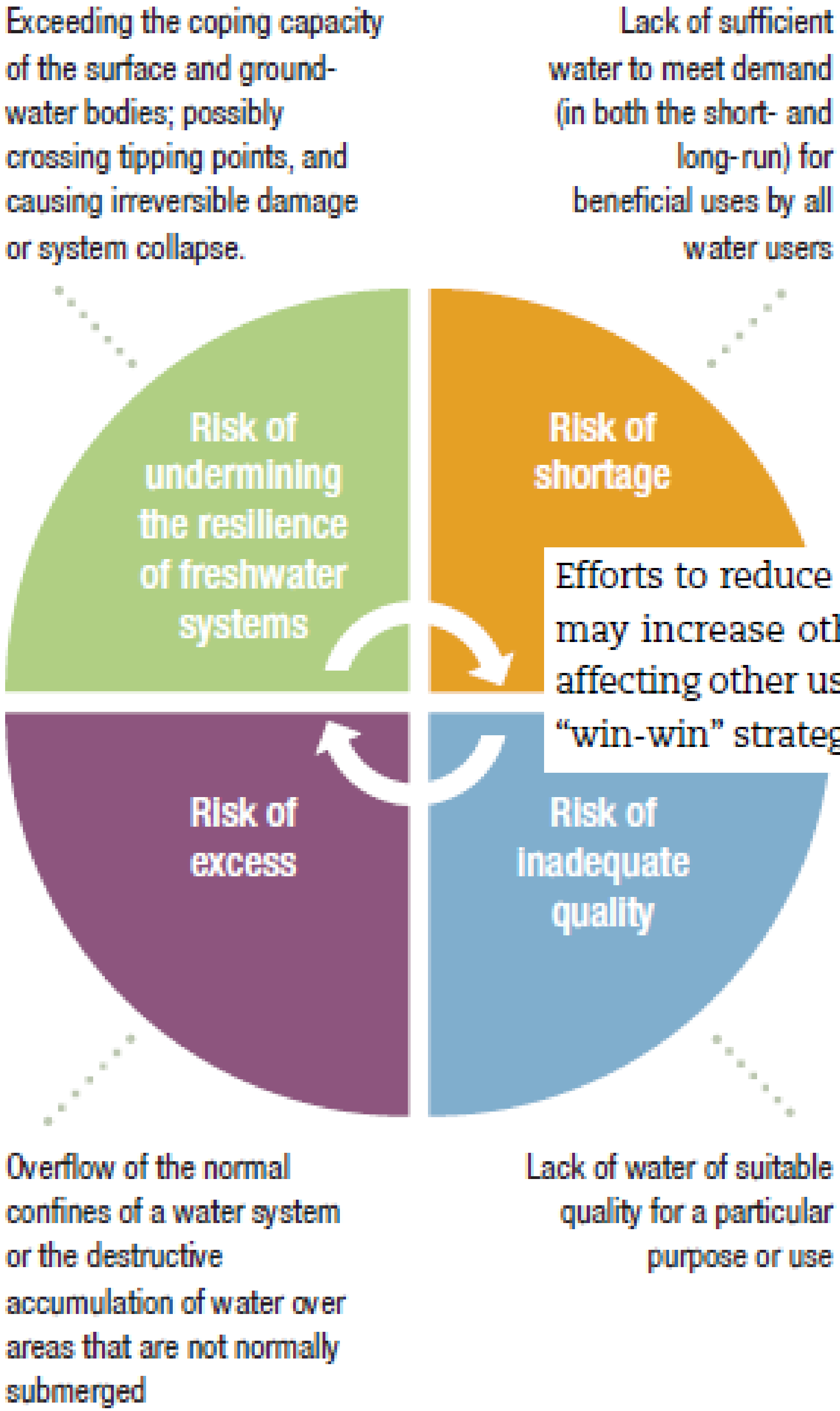
	2005	2006	2007	2008	2009	2010	2011	2012	Post-2012
NATIONAL ADAPTATION STRATEGY	Finland	Chile, France, Spain	Australia, Mexico, Netherlands	Denmark, Germany, Hungary, UK		Belgium, Korea, Portugal		Austria, Ireland, Switzerland, Turkey	Czech Republic, Estonia, Greece, Israel, Italy, Norway, Poland, Slovenia, Slovak Republic
NATIONAL ADAPTATION PLAN		Spain		Finland	Mexico		France, Germany, Luxembourg, Netherlands	Austria, Denmark, Turkey	Belgium, Chile, Estonia, Hungary, Israel, Poland, Portugal, Slovenia, Switzerland, UK

Source: OECD (2013), *Water and Climate Change Adaptation: Policies to Navigate Uncharted Waters*, OECD Studies on Water, OECD Publishing. http://dx.doi.org/10.1787/9789264200449-en.

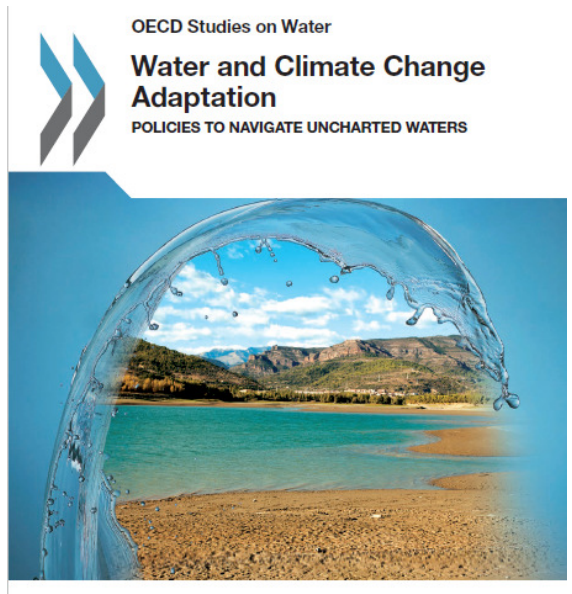
- **Indirect pressures from human responses to climate change** (both adaptation and mitigation) **could have a greater impact on water bodies than climate change itself**
- These pressures include:
  - elevated water abstractions for irrigation,
  - new flood defence infrastructure,
  - intense production of energy crops
  - etc



Weigh efforts *vs* trade-offs !



Efforts to reduce a given water risk (e.g. shortage) for one group of users, such as farmers, may increase other water risks (e.g. undermining the resilience of freshwater systems) affecting other users, such as fish. Weighing these "**risk-risk trade-offs**" can help to identify "win-win" strategies and to reduce inefficiencies and inequities in managing water risks.



2013

Examples of CC mitigation measures

– Carbon dioxide capture and storage
– Ocean fertilization with iron
– Geothermal energy extraction
– Large-scale biofuel production
– Hydro-electric power plants
– Land management for soil carbon conservation
– Agricultural intensification e.g. crop rotation
– Evaporative cooling in building

Examples of CC adaptation measures

- "Win-win" measures
  - Reduction of water use
  - Optimization of fertilizer use
  - Buffer strips
- "No regret" measures
  - Restoration of natural river beds and flood plains
  - Restoration of wetlands
  - Reforestation
  - Erosion control measures
- Potentially counter-productive measures
  - "Naturalisation" of rivers in densely populated areas
  - Dam construction
  - Modifications of land-use practices

The measures could be grouped by the three simple principles

- Keep things in place
- Keep things natural
- Be informed and plan your actions

Keep things in place

- *Keep carbon in its present pools*
- *Keep water in the catchment by creating retention basins and slowing down the run-off*
- *Keep substances at source avoiding them becoming pollutants*
- *Keep species within their natural habitats*

Keep things natural

- Protect and restore the natural regulating function of catchments, rivers, floodplains and coasts in order to manage water quality and to alleviate flood and coastal erosion risk.
- This could involve flow modification, floodplain reconnection instream and coastal habitat improvement, and riparian management.
- Restoring degraded peat bogs and reforestation will also help to slow run-off and increase infiltration.

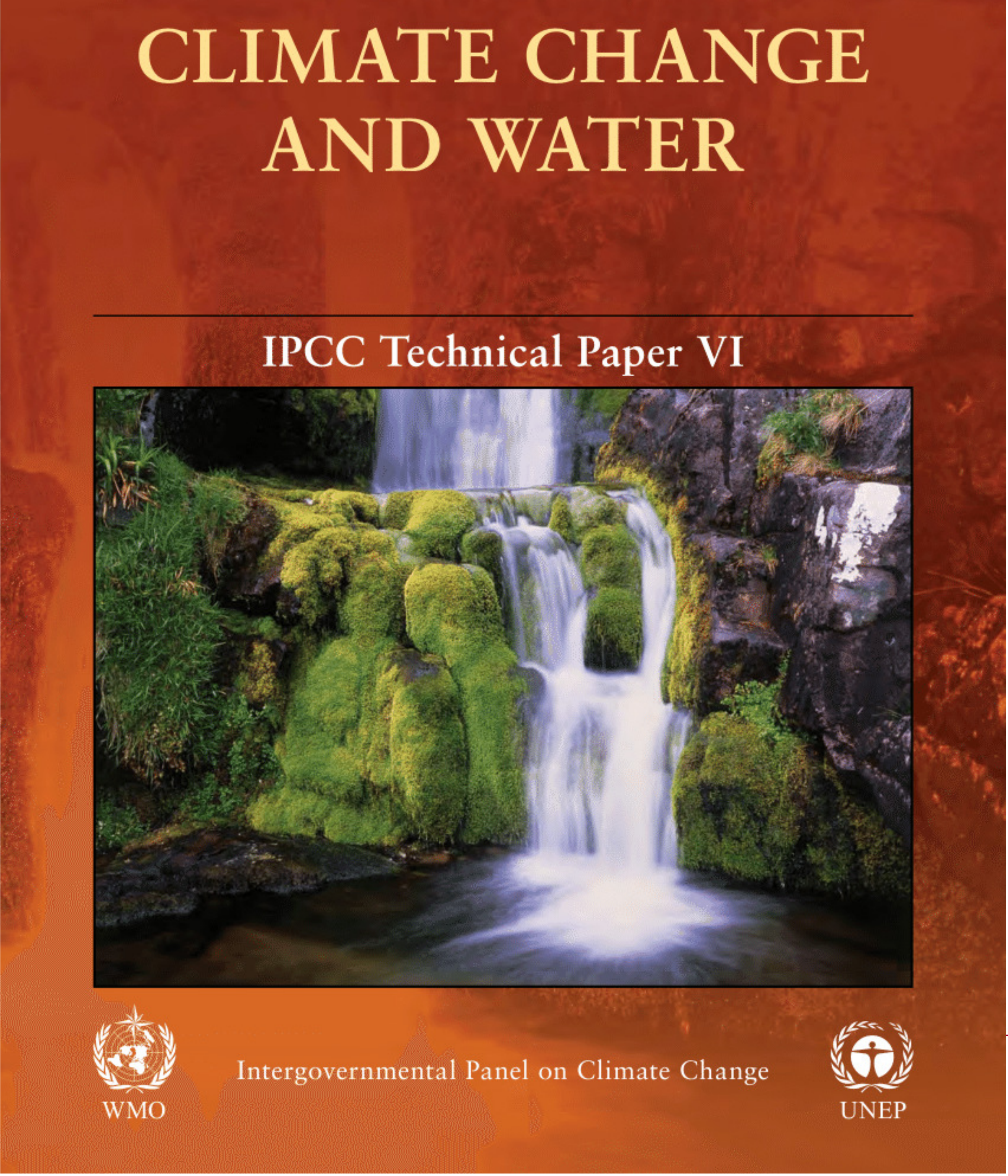
Be informed and plan your actions

- *Uncertainty and the precautionary principle*
- *Long term capacity development*
- *Medium-term management*
- *Operative measures*
- *Streamlining of strategies and avoiding potential cross-sectoral trade-offs in river basin management*

Potential trade-offs in water sector

- **It is well-known that**
  - large-scale biofuel production increases water demand and contamination
  - hydro-electric power plants fragmentise the river ecosystem integrity and affect biodiversity
  - dams and water reservoirs can emit additional GHGs
  - seawater desalination as a drought combating measure accelerates energy consumption.
- **It is much less known that**
  - even **reforestation**, **wetland reconstruction**, or creating **buffer strips**, usually considered as win-win measures, may locally become antagonistic to other adaptation and mitigation measures.

Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., 2008: Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp.



IPCC 4AR addresses CC mitigation tradeoffs

- Mitigation measures can influence water resources and their management.
- Water management policies and measures can have an influence on GHG emissions.
- Interventions in the water system might be counter-productive when evaluated in terms of CC mitigation.

CLIMATE CHANGE AND WATER

IPCC 4AR

Table 6.1: Influence of sector-specific mitigation options (or their consequences) on water quality, quantity and level. Positive

Influence of sector-specific mitigation options on water quality

Water aspect	Energy	Buildings	Industry	Agriculture	Forests	Waste
Quality						
Chemical/ biological	CCS(1) [?] Bio-fuels(2) [+/-] Geothermal energy(5) [-] Unconvention[al] oil(13) [-]		CCS(1) [?] Wastewater treatment(12) [-] Biomass electricity(3) [-/?]	Land-use change and management (7) [+/-] Cropland management (water)(8) [+/-]	Afforestation (sinks)(10) [+]	Solid waste management; Wastewater treatment(12) [+/-]
Temperature	Biomass electricity(3) [+]			Cropland management (reduced tillage) (9) [+/-]		

(1) Carbon capture and storage (CCS) underground pos ... er quality; deep-sea storage (below 3,000 m water depth and a few hundred metres of sediment) seems to be the safest option.

(2) Expanding bio-energy crops a ... use changes, leading to indire

(3) Biomass electricity: in general ... water to the surface water.

(5) Geothermal energy use

(7) Land-use change and manage ... the (local) hydrological cycle (

(8) Agricultural practices for mitig

(9) Reduced tillage promotes incr

(10) Afforestation generally improv ... thus reducing runoff and floodi ... in semi-arid and arid regions.

(12) The various waste manageme ... but they may cause water poll

(13) As conventional oil supplies b ... greater environmental costs (

Expanding bio-energy crops and forests may cause increased water demand, contamination of underground water and landuse changes

Geothermal energy use might result in pollution, subsidence and a claim on available water resources.

Unconventional liquid fuels will become more economically attractive, but this is offset by greater environmental costs (a high water demand; sanitation costs).

CLIMATE CHANGE AND WATER

IPCC 4AR

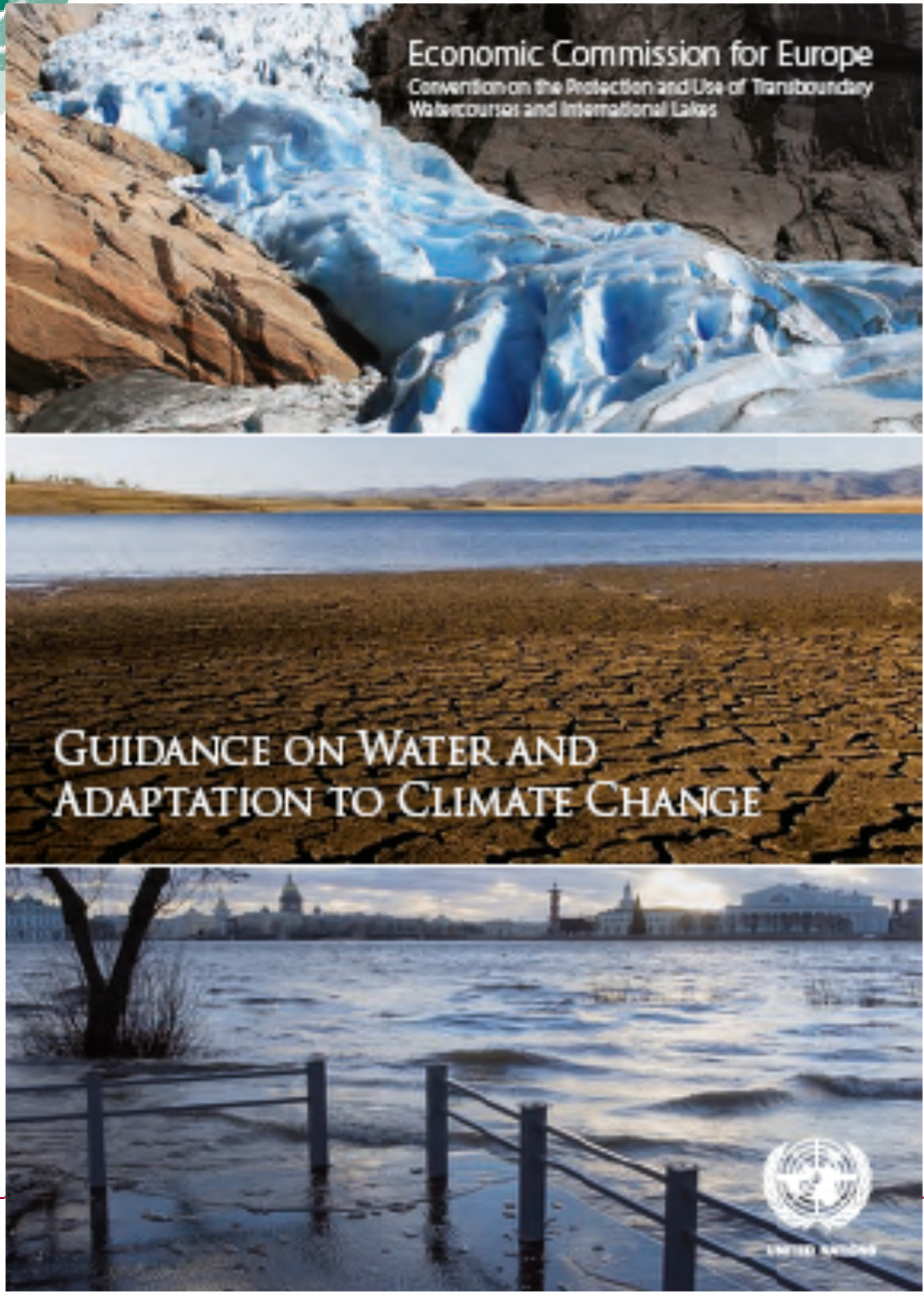
Table 6.1: Influence of sector-specific mitigation options (or their consequences) on water quality, quantity and level. Positive

Influence of sector-specific mitigation options on water quantity

Water aspect	Energy	Buildings	Industry	Agriculture	Forests	Waste
Quantity						
Availability/ demand	Hydropower[4] [+/-] Unconventional oil[13] [-] Geothermal energy[5] [-]	Energy use in buildings[6] [+/-]		Land-use change and management [7] [+/-] Cropland management (water)[8] [-]	Afforestation [10] [+/-] Avoided/ reduced deforestation [11] [+]	Wastewater treatment[12] [+]
Flow/runoff/ recharge	Bio-fuels[2] [+/-] Hydropower [4] [+/-]			Cropland management (reduced tillage) [9] [+]		

Land-use change can influence water quality (enhanced or reduced leaching of nutrients and pesticides) and the hydrological cycle (higher water use). **Agricultural practices for mitigation** can have both positive and negative effects on conservation of water and on its quality. **Reduced tillage** promotes increased water-use efficiency.

Afforestation influences both catchment and regional hydrological cycles reducing runoff and flooding. It generally gives better watershed protection, but at the expense of surface water yield and aquifer recharge, which may be critical in semi-arid and arid regions.



UNITED NATIONS
New York and Geneva, 2009

Addresses cross-sectoral tradeoffs

Effective adaptation to climate change requires a cross-sectoral approach in order to prevent possible conflicts and to consider trade-offs and synergies between adaptation and mitigation measures.

UNITED NATIONS
New York and Geneva, 2009

Guidance on Water and Adaptation to Climate Change

Box 2: Possible Trade-offs Between Adaptation and Mitigation Measures

Mitigation measures ⇒ water resources

Examples of proposed mitigation measures and possible impacts on water resources

Mitigation measure	Possible risks for water resources	Possible positive effects	Possible remedies and comments

CO2 capture and storage might cause degradation of groundwater quality due to leakage of CO2 from injection and abandoned wells, leakage across faults and ineffective confining layers, local health and safety concerns due to release of CO2

Geothermal energy extraction might cause chemical pollution of upper layers of fresh aquifers and waterways due to trace amounts of dangerous elements such as mercury, arsenic, and antimony; concerns regarding land subsidence.

Large-scale biofuel production might cause increased water demand, enhanced leaching of pesticides and nutrients leading to contamination of water, biodiversity impacts, conflicts with food production and land use changes, leading to indirect effects on water resources, increased vulnerability to droughts

BOX 2: POSSIBLE TRADE-OFFS BETWEEN ADAPTATION AND MITIGATION MEASURES

Mitigation measures ⇒ water resources

EXAMPLES OF PROPOSED MITIGATION MEASURES AND POSSIBLE IMPACTS ON WATER RESOURCES

MITIGATION MEASURE	POSSIBLE RISKS FOR WATER RESOURCES	POSSIBLE POSITIVE EFFECTS	POSSIBLE REMEDIES AND COMMENTS
Hydro-electric power plants	Ecological impacts on existing river ecosystems and fisheries	Possibly flow regulation, flood control, availability of water	Mitigation effect of large hydropower dams is contested. Appropriate … can help to remedy negative effects.

Hydro-electric power plants have ecological impacts on existing river ecosystems and fisheries for example due to changes in flow regime, water temperature regime, oxygen concentrations and evaporation.

Land management for soil carbon conservation might cause enhanced contamination of groundwater with nutrients or pesticides via leaching under reduced tillage

Agricultural intensification might increase the crops with higher water demand

MITIGATION MEASURE	POSSIBLE RISKS FOR WATER RESOURCES	POSSIBLE POSITIVE EFFECTS	POSSIBLE REMEDIES AND COMMENTS
Evaporative cooling in buildings	High water demand	Reduced energy demand	Reducing the cooling load by optimizing building shape and orientation

UNITED NATIONS
New York and Geneva, 2009

GUIDANCE ON WATER AND ADAPTATION TO CLIMATE CHANGE

BOX 2: POSSIBLE TRADE-OFFS BETWEEN ADAPTATION AND MITIGATION MEASURES

Adaptation measures ⇒ negative effect on CC mitigation

EXAMPLES OF ADAPTATION MEASURES IN THE WATER SECTOR WHICH CAN HAVE NEGATIVE IMPACTS ON CLIMATE CHANGE MITIGATION

Desalinization of saline water for water supply involves high energy needs

Desalinization of saline water for water supply	High energy needs	Mitigation impact depends on energy source, therefore use desalinization only if no other choices, and use renewable energy
Reservoirs/ hydropower plants	Can emit GHGs as water conveys carbon in the natural carbon cycle and due to the rotting vegetation	Mitigation effect depends on many factors, including depth of reservoir. Multi-purpose dams and appropriate location and management are recommended, but more research is needed
Irrigation	High water and energy needs	Use efficient irrigation techniques, drought-resistant crop varieties. Mitigation effect depends on energy source

Reservoirs/ hydropower plants can emit GHGs

Irrigation involves high water and energy needs

Afforestation / reforestation & CC mitigation

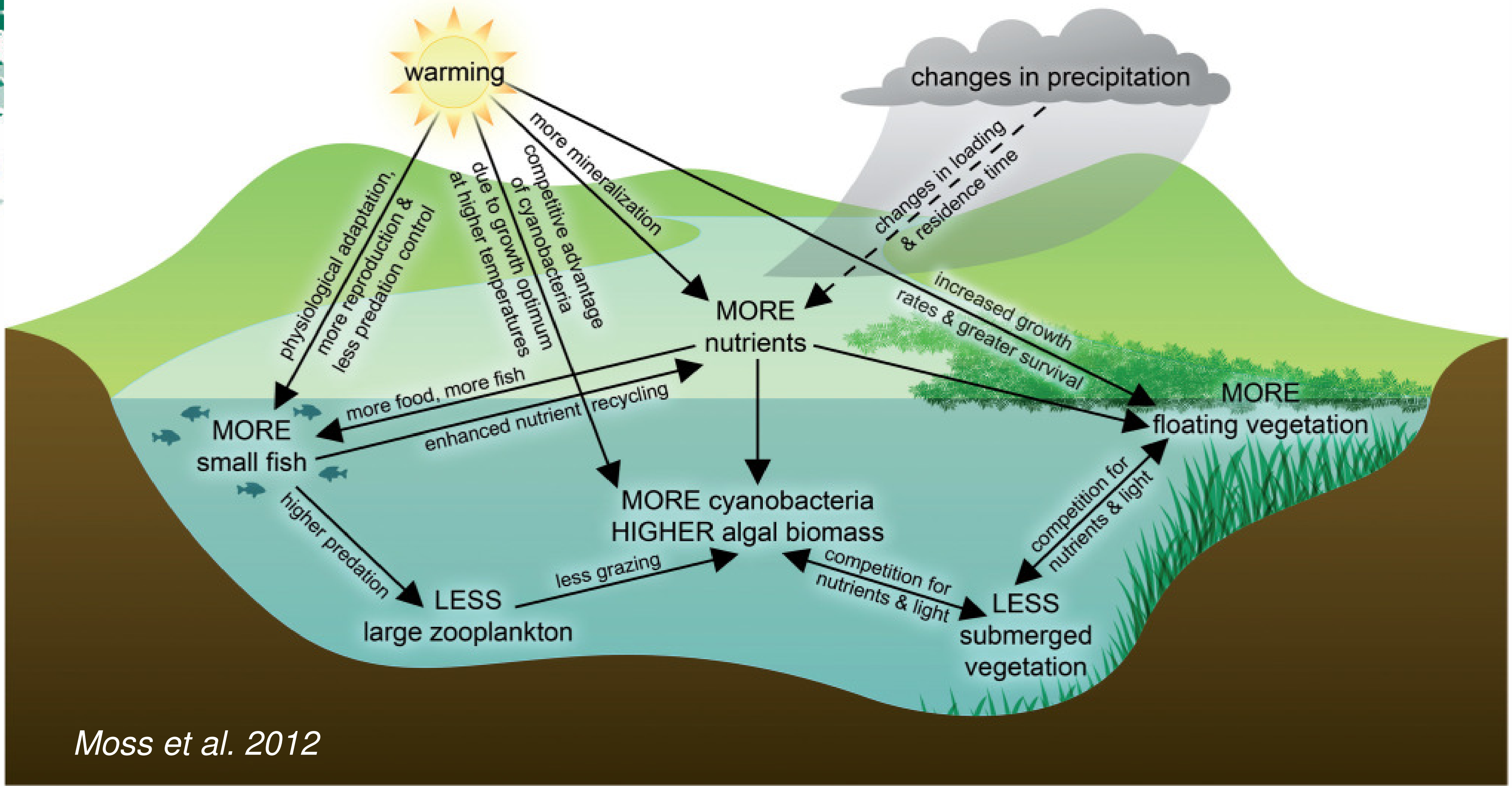
•Carbon sequestration strategies with tree plantations do not consider their full environmental consequences.
•Plantations decreased stream flow by 227 millimeters per year globally (52%), with 13% of streams drying completely for at least 1 year.
•Plantations can help control groundwater recharge and upwelling but reduce stream flow and salinize and acidify some soils.

Jackson RB et al. 2005. Trading water for carbon with biological sequestration. Science 310: 1944–47.

Principles for linking adaptation measures and mitigation activities (Robledo et al., 2005):

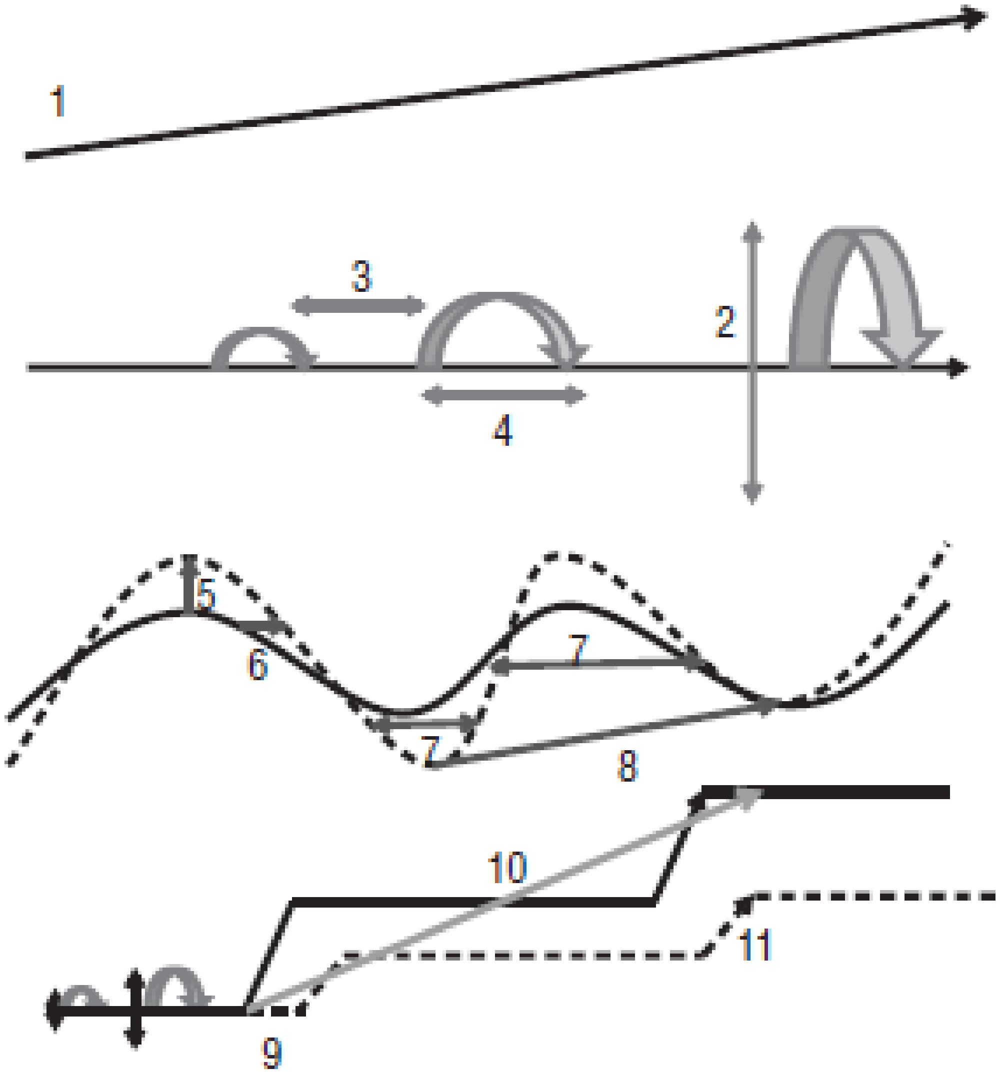
1. Prioritise mitigation activities that help to reduce pressure on the natural resources and enhance local adaptive capacity (synergy effect);
2. Include vulnerability to climate change as one of the risks to be analysed in mitigation activities;
3. Increase sustainability of livelihoods, with particular consideration for the poor.

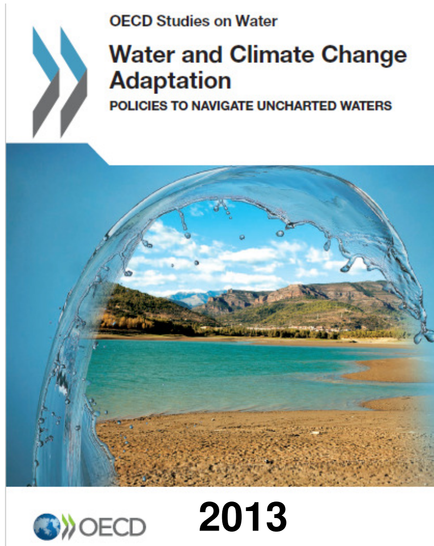
Global warming reinforces eutrophication !



Eesti Maaülikool
Estonian University of Life Sciences
www.emu.ee

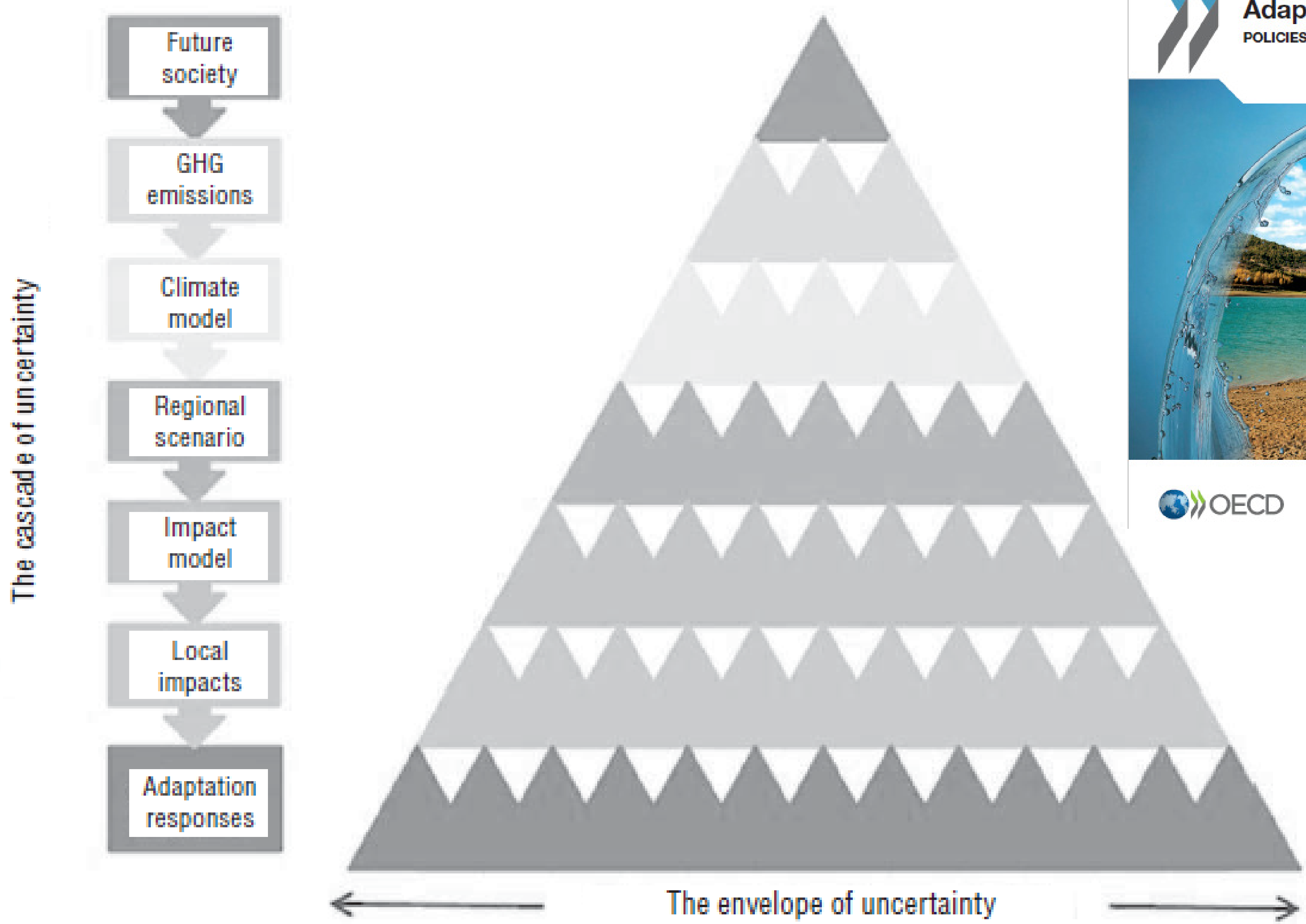
Figure 1.1. **Modes of climate change**

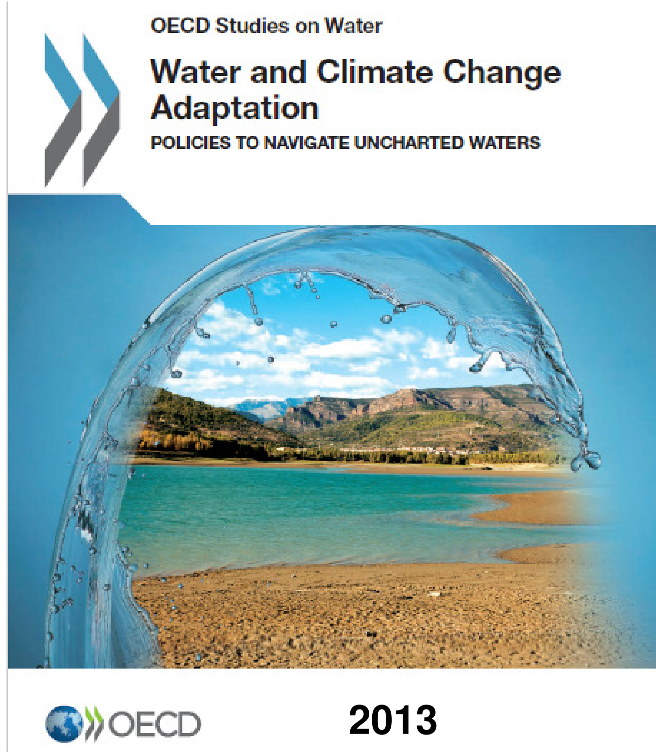




Source: A.J. and J.H. Matthews (2012), Adapted from "Vulnerability to What Change?", presented at the UNFCCC Technical workshop on water, climate change impacts and adaptation strategies, Mexico City, Mexico 18-20 July, World Wildlife Fund and Conservation International, *http://unfccc.int/adaptation/workshops_meetings/nairobi_work_programme/items/6955.php* (accessed 12 December 2012).

Figure 1.2. **Cascade of uncertainty**





A cascade of uncertainty proceeds from different socio-economic and demographic pathways, their translation into concentrations of atmospheric greenhouse gas (GHG) concentrations, expressed climate outcomes in global and regional models, translation into local impacts on human and natural systems and adaptation responses.

Source: Wilby, R.L. and S. Dessai (2010), "Robust Adaptation to Climate Change", *Weather*, Vol. 65/7, Royal Meteorological Society, Reading, pp. 180-185, *http://dx.doi.org/10.1002/wea.543*.

nature COMMUNICATIONS

ARTICLE

Received 18 Jun 2013 | Accepted 14 Nov 2013 | Published 17 Dec 2013

DOI: 10.1038/ncomms3934

Human-induced nitrogen–phosphorus imbalances alter natural and managed ecosystems across the globe

Josep Peñuelas[1,2], Benjamin Poulter[3], Jordi Sardans[1,2], Philippe Ciais[3], Marijn van der Velde[4], Laurent Bopp[3], Olivier Boucher[5], Yves Godderis[6], Philippe Hinsinger[7], Joan Llusia[1,2], Elise Nardin[6], Sara Vicca[8], Michael Obersteiner[4] & Ivan A. Janssens[8]

– The carbon balance of aquatic and watershed terrestrial ecosystems is tightly linked with cycles of other nutrients, first of all with nitrogen and phosphorus, and with the CNP stoichiometry in food webs.

– All these processes are sensitive to climate change (CC) and transform as a result of global trends.

Locatelli, B., 2016. Ecosystem Services and Climate Change.

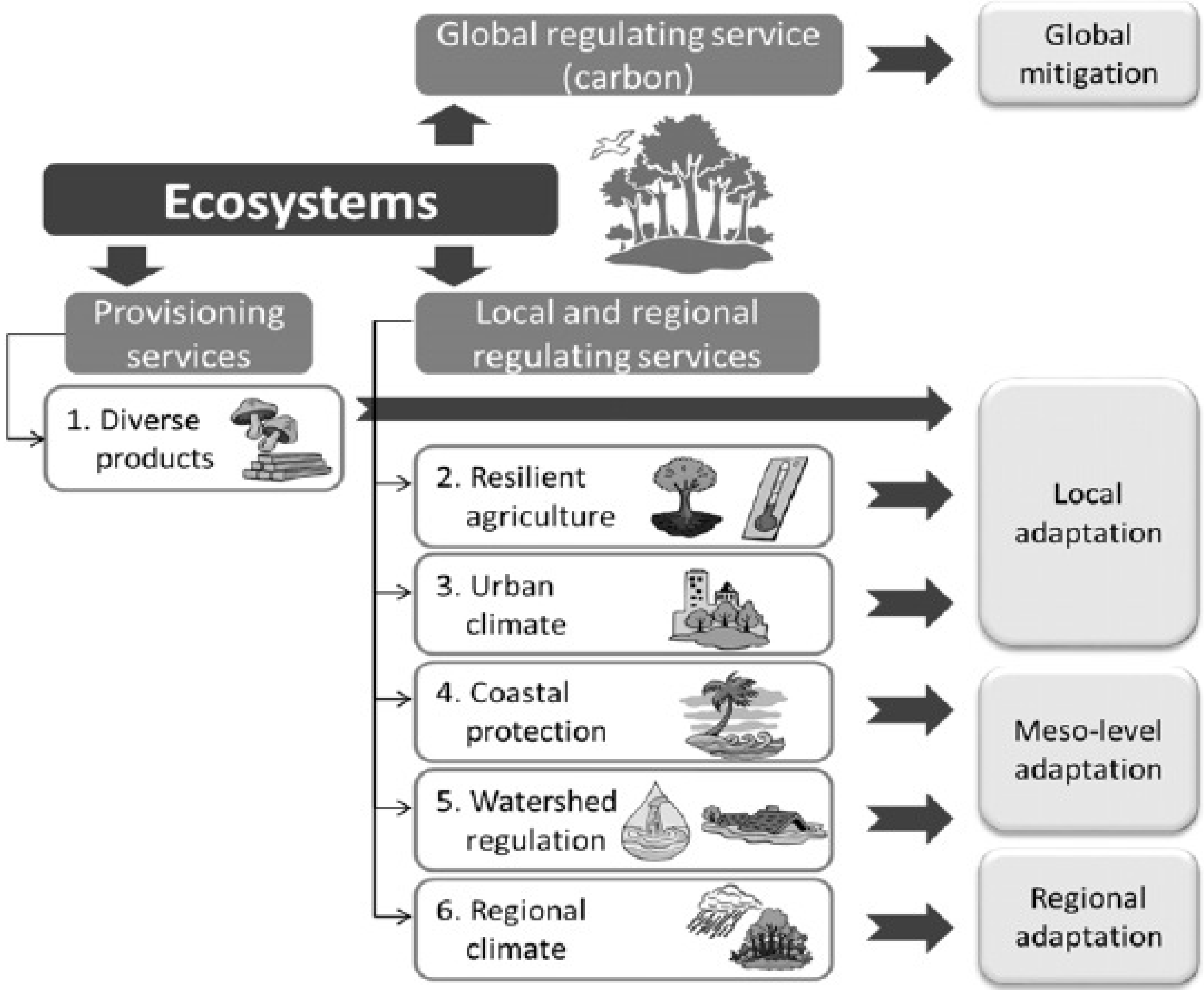


Figure 38.2 Contribution of ecosystem services to climate change adaptation and mitigation

2014

3 Freshwater Resources

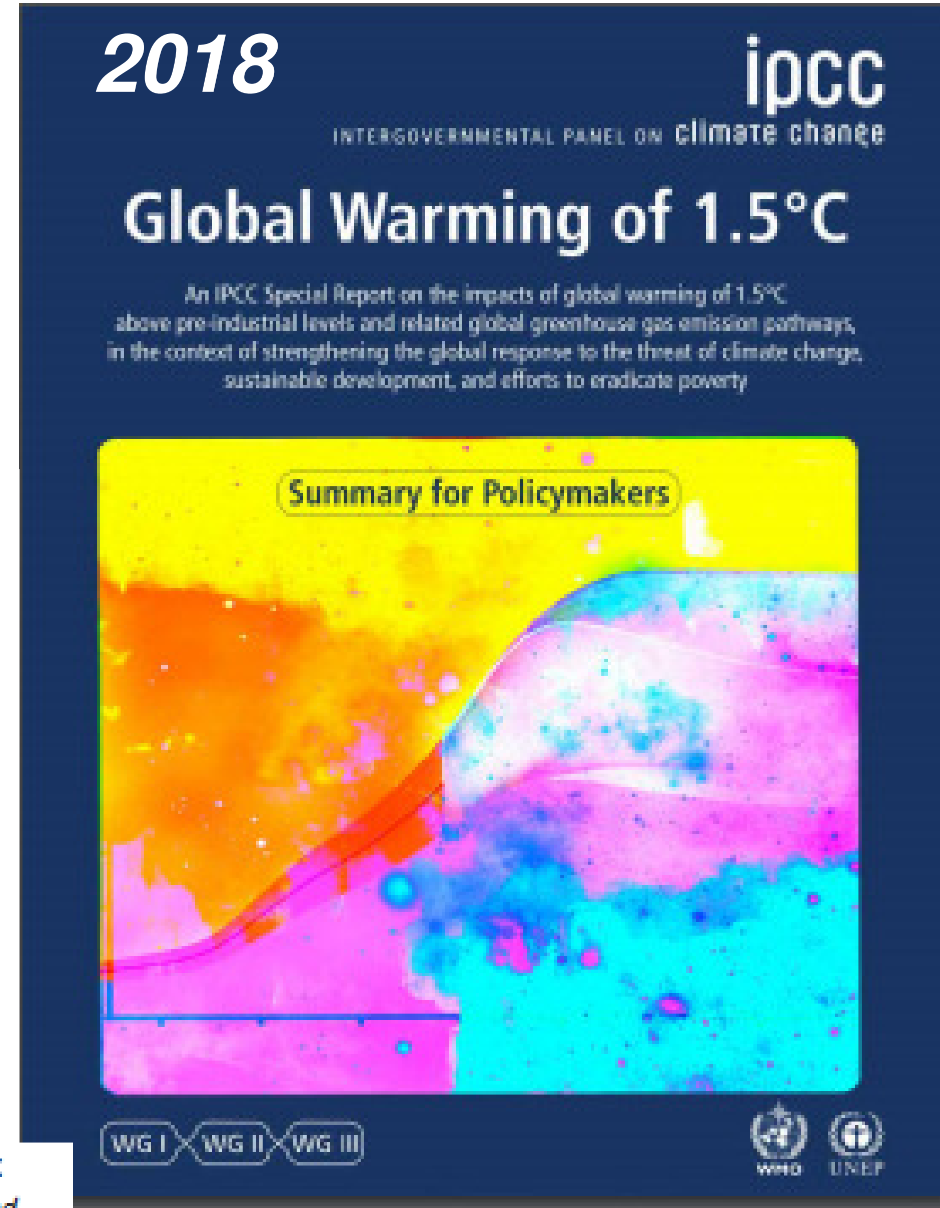
Coordinating Lead Authors:
Blanca E. Jiménez Cisneros (Mexico), Taikan Oki (Japan)

Lead Authors:
Nigel W. Arnell (UK), Gerardo Benito (Spain), J. Graham Cogley (Canada), Petra Döll (Germany), Tong Jiang (China), Shadrack S. Mwakalila (Tanzania)

Contributing Authors:
Thomas Fischer (Germany), Dieter Gerten (Germany), Regine Hock (Canada), Shinjiro Kanae (Japan), Xixi Lu (Singapore), Luis José Mata (Venezuela), Claudia Pahl-Wostl (Germany), Kenneth M. Strzepek (USA), Buda Su (China), B. van den Hurk (Netherlands)

Review Editor:
Zbigniew Kundzewicz (Poland)

Volunteer Chapter Scientist:
Asako Nishijima (Japan)



Jiménez Cisneros, B.E., T. Oki, N.W. Arnell, G. Benito, J.G. Cogley, P. Döll, T. Jiang, and S.S. Mwakalila, 2014: Freshwater resources. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 229-269.

2018

ipcc

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

- Signatories to the Paris Climate Agreement in 2017 pledged to keep global average air temperatures rise less than 2 °C above pre-industrial levels.
- Almost everyone also promised to keep the temperature rise below 1.5 °C.
- The report acknowledges that the goal is becoming more and more difficult, but not completely impossible.
- To meet the 1.5 °C goal, the whole world should cut its carbon emissions more vigorously. Of the world's major polluters, only Morocco and the Gambia fulfill the 1.5 ° C promise.
- Of the major world powers, only India and the Philippines are struggling to keep temperatures rise below 2 ° C.
- The average temperature in the world is going to increase by 3 °C due to the sluggishness of the countries
- To date, global average air temperature has risen by almost 1 °C. If present emissions continue, it will rise 0.5 °C already by 2030, and we will reach warming of 2 °C in 2060-2080.

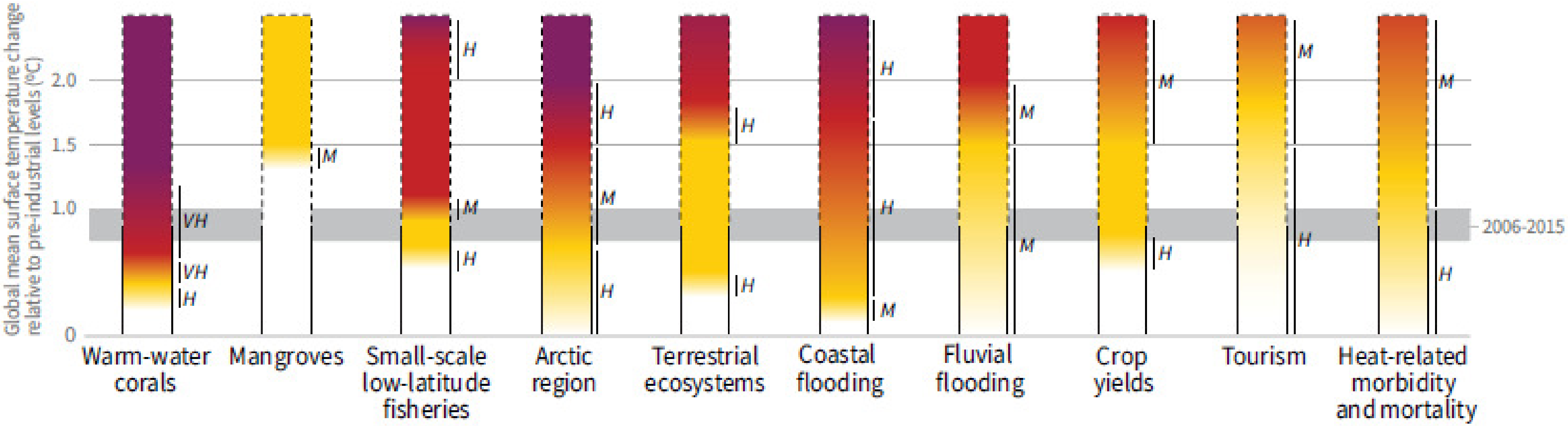
2018

ipcc 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

Impacts and risks for selected natural, managed and human systems



Confidence level for transition: *L*=Low, *M*=Medium, *H*=High and *VH*=Very high

Crossing the 2 °C limit is associated with enormous economic and social damage, an increase in heat waves, floods and fires, the collapse of many ecosystems and their functions, the acidification of the oceans, the depletion of fish stocks and the loss of suitable conditions for agriculture in large areas.

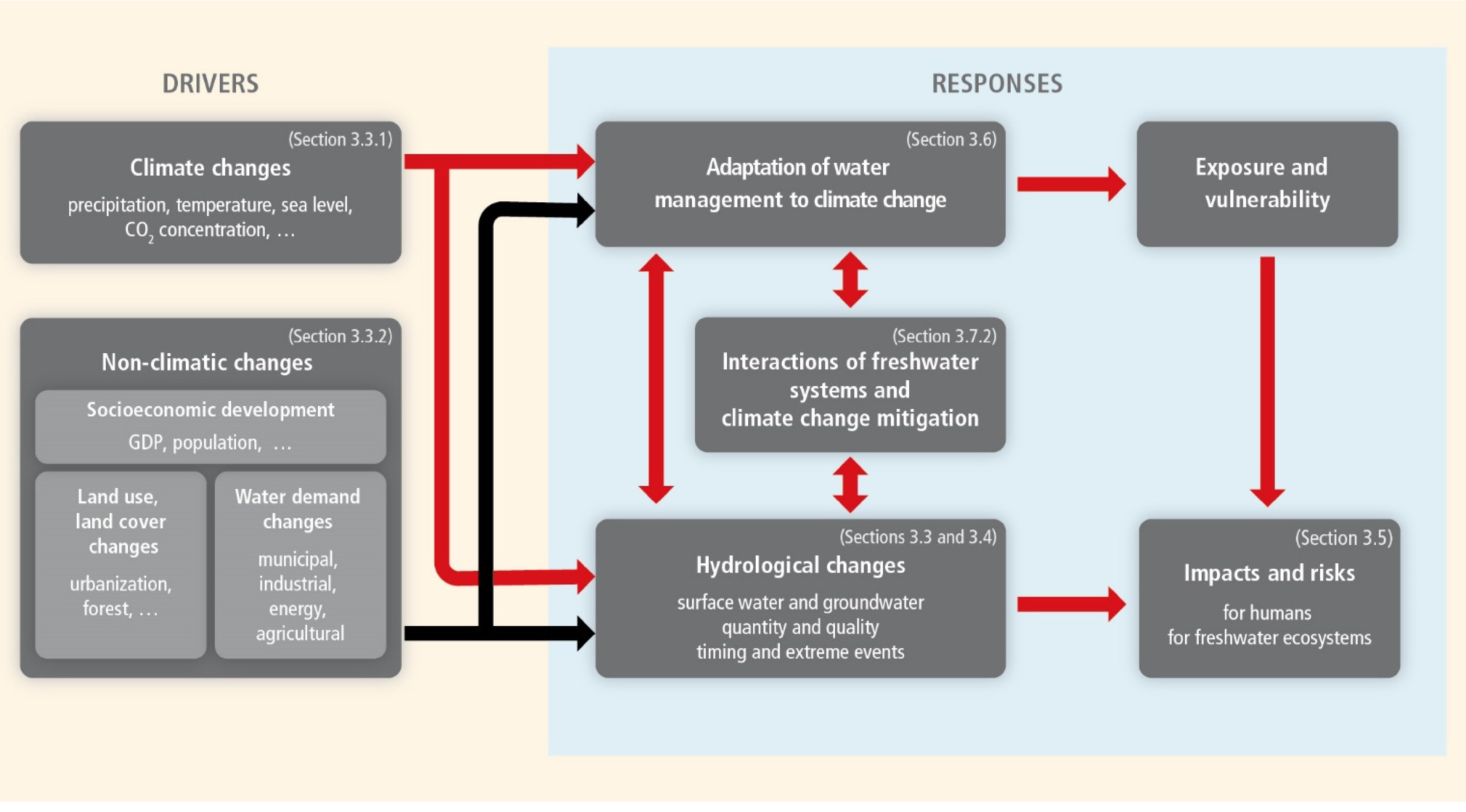
2018 ipcc INTERGOVERNMENTAL PANEL ON climate change

Global Warming of 1.5°C

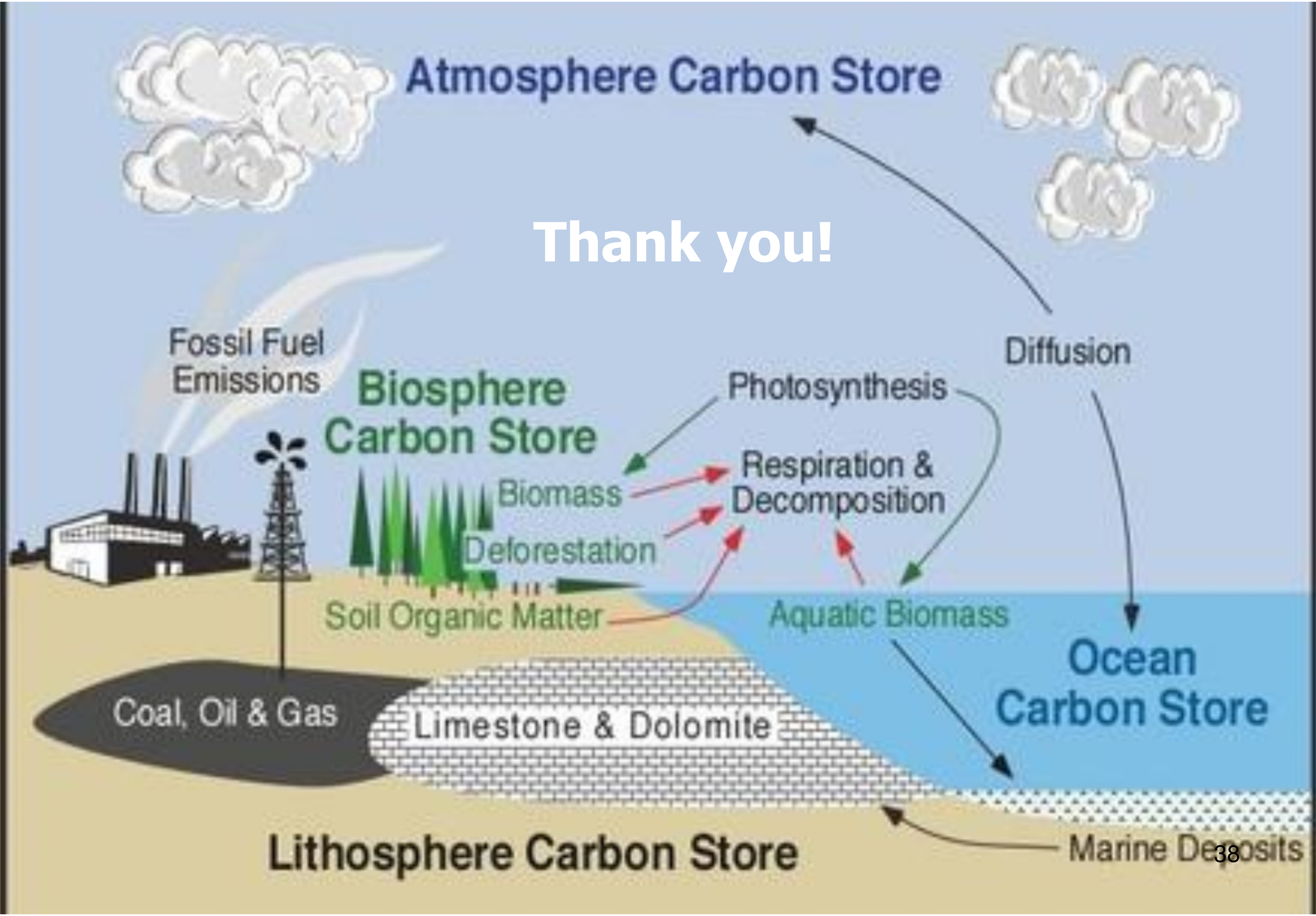
An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

- 1.5 °C rise in temperature compared to a 2 °C rise would significantly reduce the risks:
  - Extreme heat waves would affect less 61 million people worldwide.
  - In the Mediterranean, twice as few people would suffer from water scarcity.
  - 150 million premature deaths could be prevented worldwide by 2100.
- Costs could be reduced by speeding up the world.
  - in 2016-2035 $ 2.4 trillion per year would be needed to invest in green energy systems.
  - This is four times less than the losses caused by the rise of the world ocean in 2100.

Impact of climate change on inland water bodies and their management AR5 2014



Thank you!


Atmosphere Carbon Store
Fossil Fuel Emissions
Biosphere Carbon Store
Diffusion
Photosynthesis
Respiration & Decomposition
Biomass
Deforestation
Soil Organic Matter
Aquatic Biomass
Ocean Carbon Store
Coal, Oil & Gas
Limestone & Dolomite
Lithosphere Carbon Store
Marine Deposits