THE FUTURE OF COOLING
AND ITS LINKS TO THE SUSTAINABLE DEVELOPMENT GOALS

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PERSPECTIVE

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Cooling for sustainable development

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The unprecedented rise in cooling demand globally is a critical blind spot in sustainability debates. We examine cooling as a system comprised of active and passive measures, with key social and technical components, and explain its link to all 17 Sustainable Development Goals. We propose an analytical and solution-oriented framework to identify and shape interventions towards sustainable cooling. The framework comprehends demand drivers; cradle-to-cradle stages; and system change levers. By intersecting cooling stages and levers, we discuss four specific, exemplary interventions to deliver sustainable cooling. We propose an agenda for research and practice to transition towards sustainable cooling for all.

Author's link: https://rdcu.be/b8IXN

OUTLINE

1. **Why cooling? (the challenge)**
2. **Cooling and the SDGs**
3. **Analytical framework**
4. **Exemplary intervention points**
5. **Agenda for cooling research & practice**
6. **Our team and Programme**

WHY COOLING?

CHILLING PROSPECTS

- 1.1 billion people face immediate risks from lack of access to cooling
- 10 ACs to be sold every second for next 30 years (IEA, 2018)
- By 2050, cooling will require energy equivalent to that of USA, Europe and Japan today

Artwork by Dr. Antonella Mazzone

CHILLING PROSPECTS

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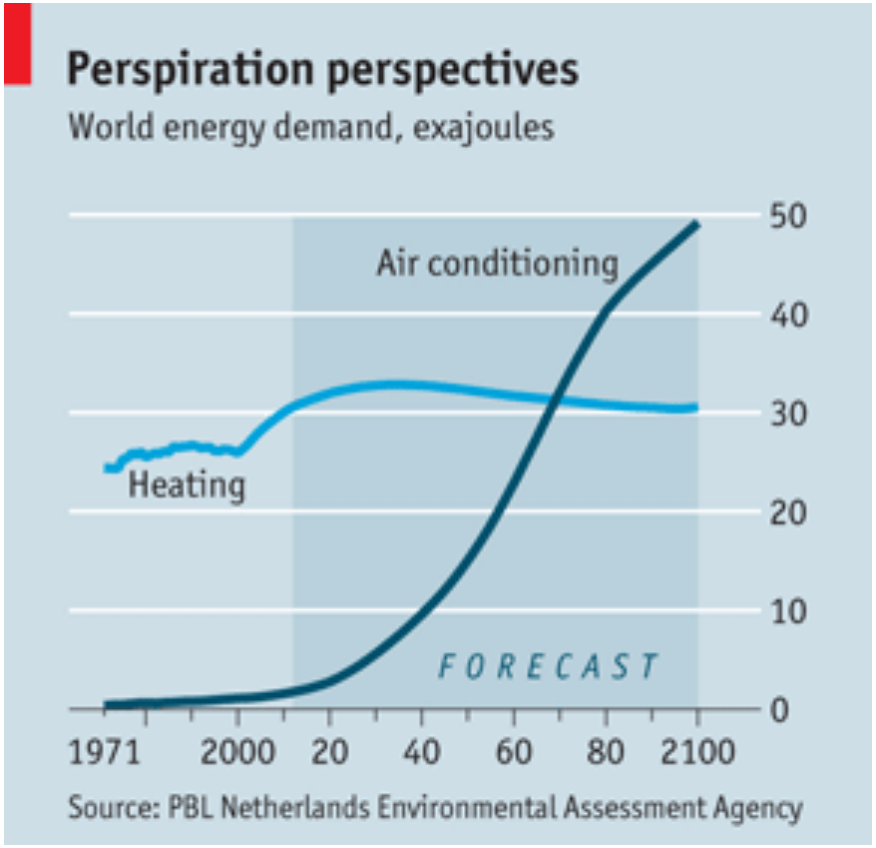
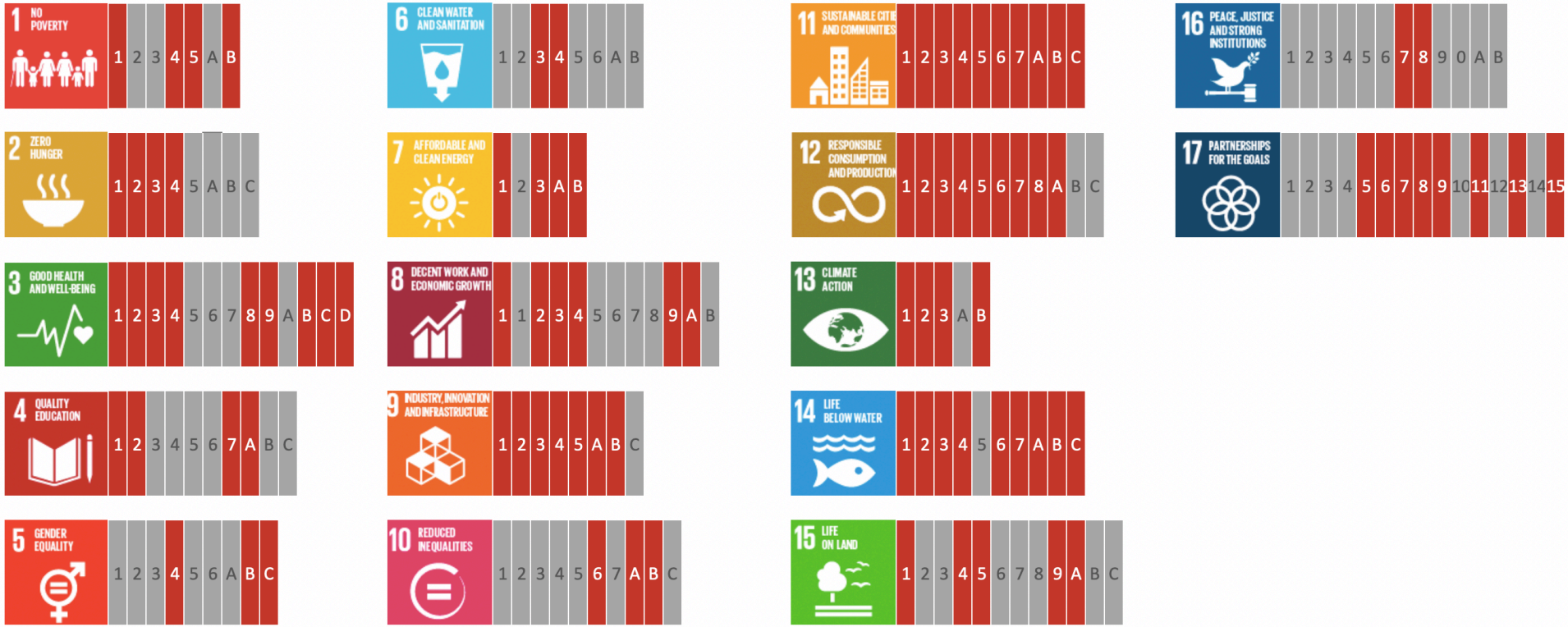


OUR WORK

- **We address two gaps:**
  - Extent of the relationship between cooling and SDGs
  - Literature does not consider a holistic approach.
- **How?**
  - Systematic review of literature
  - Develop an analytical framework
  - Propose high-potential interventions and, agenda for research and action.

COOLING AND THE SDGS

PRELIMINARY WORK



Linkages between sustainable cooling and SDG targets (Preliminary Work)

FINDING THE EVIDENCE

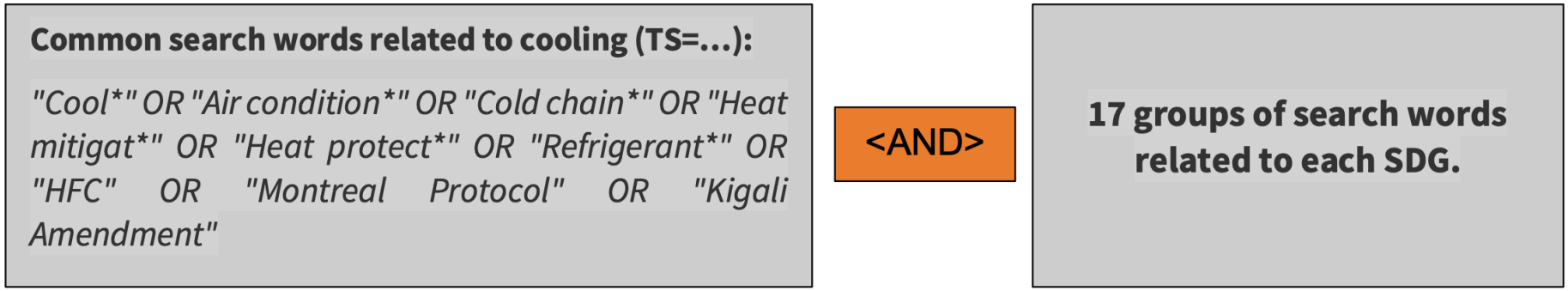
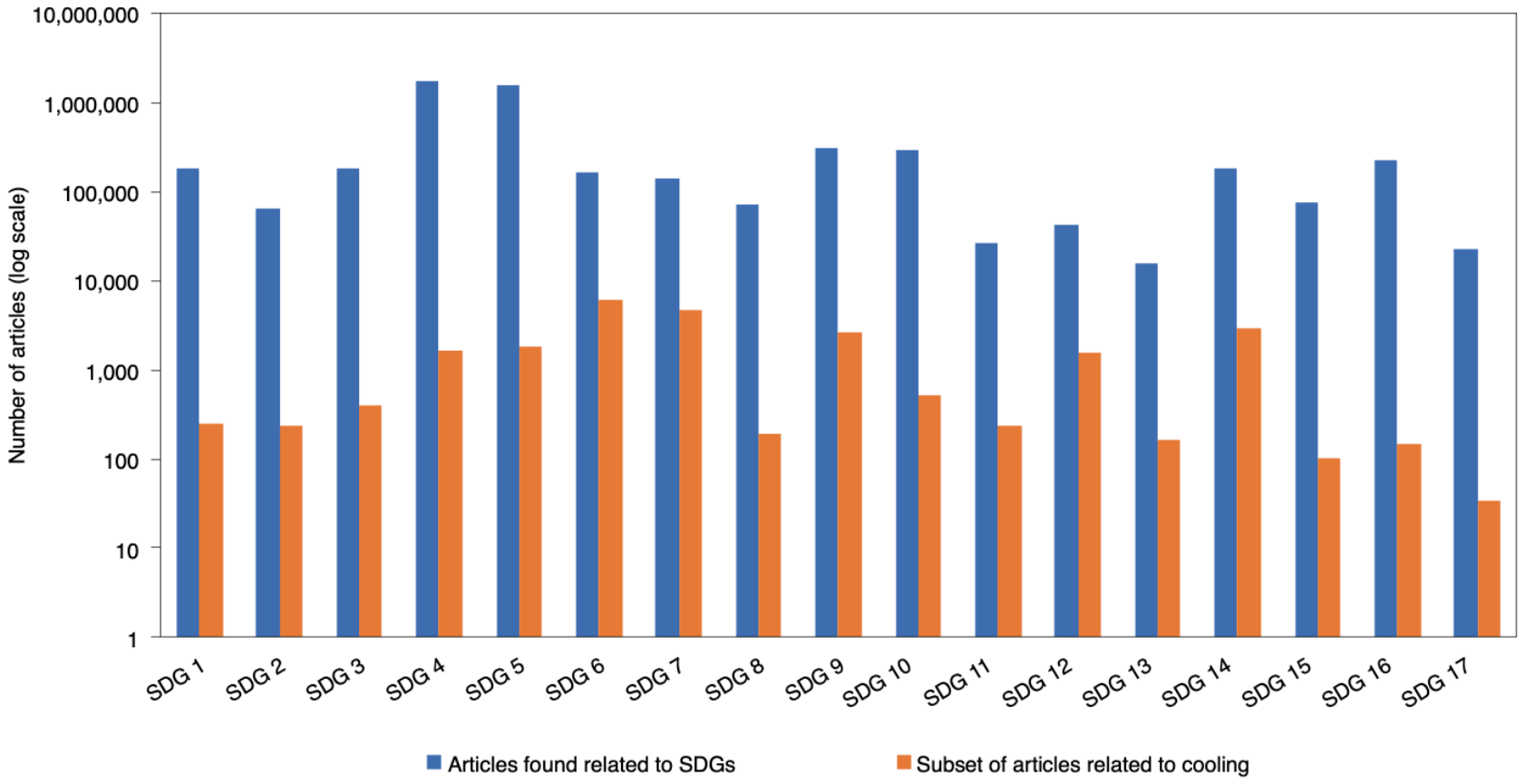


Figure A.1. Representation of the 17 searches in Web of Science.

SDG7	"Sustainable Development Goal* 7" OR "SDG 7" OR "SDG7" OR "SEforAll" OR "clean* energ* " OR "energ* access*" OR "affordab* energ*" OR "energ* affordab*" OR "renewabl* energ*"

WHAT WE FOUND



Articles found containing SDG and cooling in their topics. Cooling is directly linked to all 17 SDGs. Note that the *y* axis is on a logarithmic scale.

EXAMPLES OF COOLING LINKAGES TO SDGS

ANALYTICAL FRAMEWORK

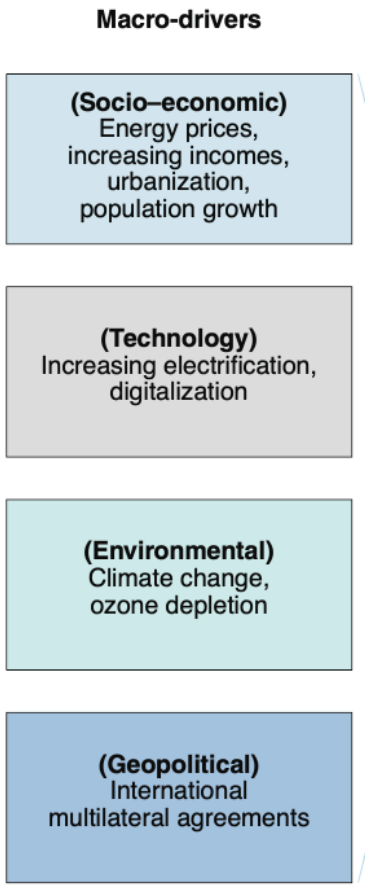
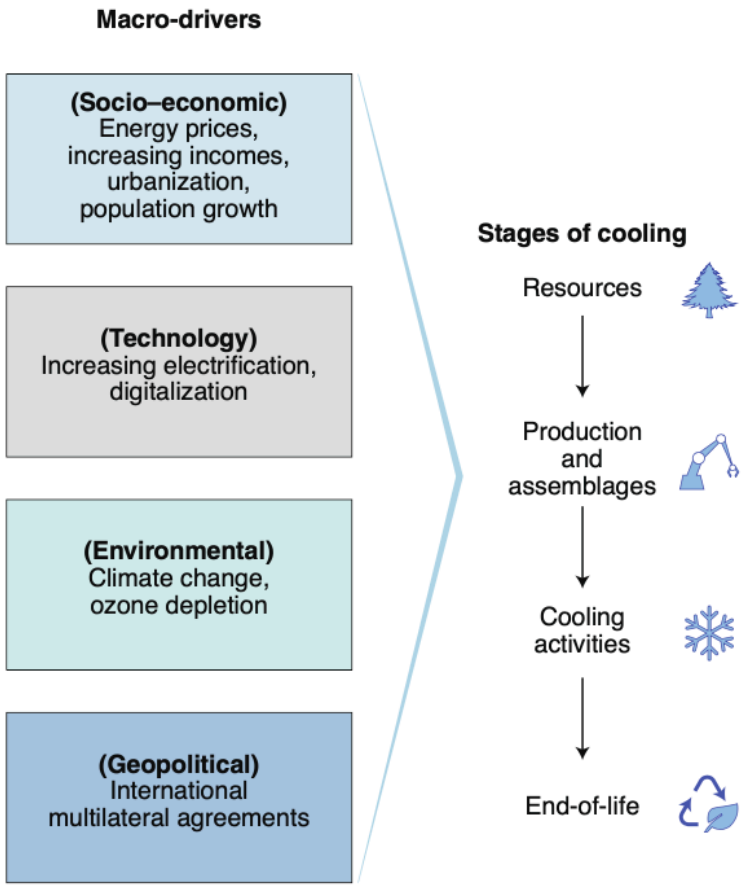


Fig. 2 | Analytical framework for transitioning towards sustainable cooling. The framework consists of macro-level drivers, the different stages of cooling delivery, and the levers which act on the cooling system to influence the trajectory of the future of cooling.



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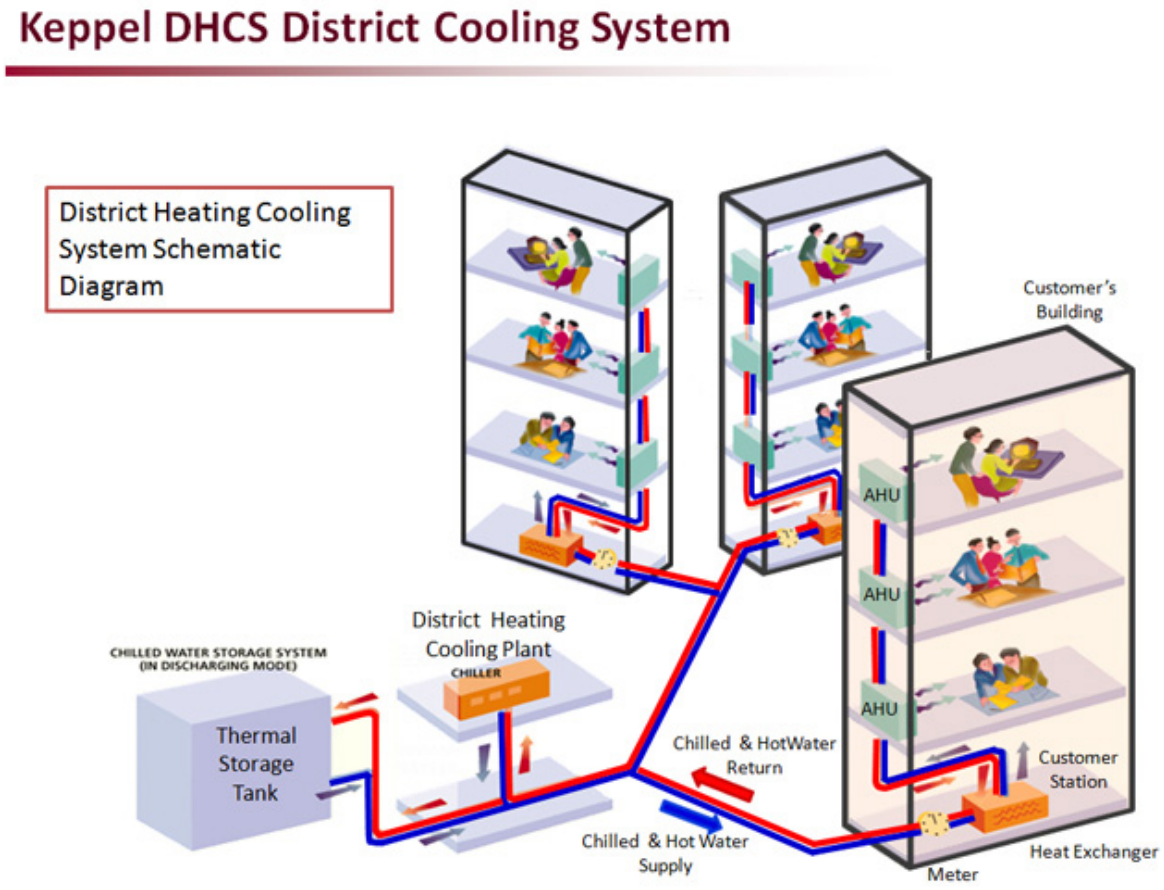
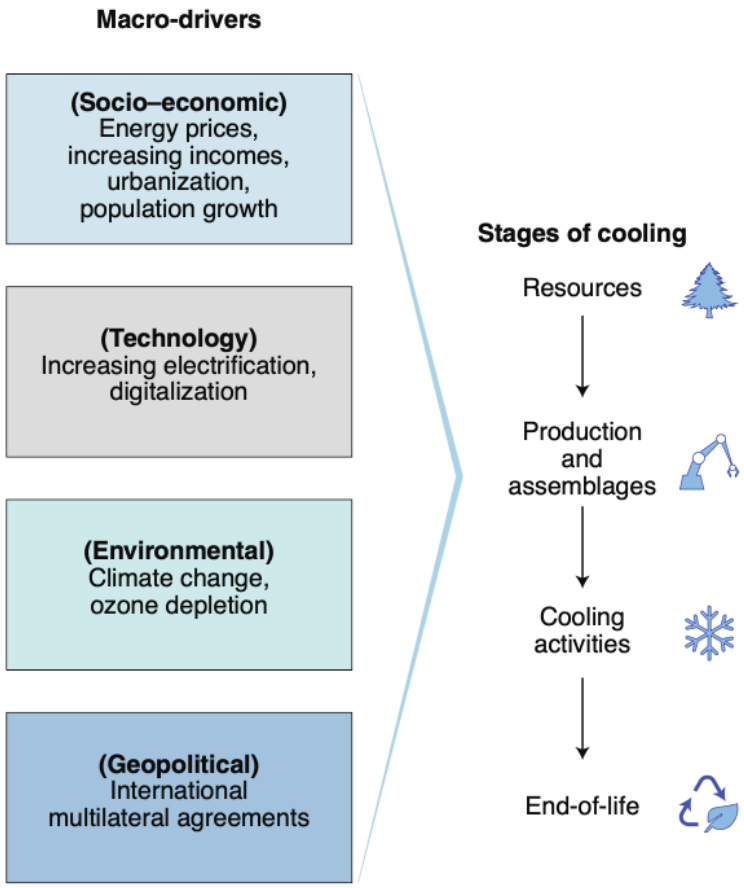
EXAMPLES ACTIVE TECHNOLOGIES

Stages of cooling	**District cooling neighbourhood network with centralized chillers.**
Resources	Metals to produce chillers, metal or plastic pipes for network and water as heat-transfer fluid.
Production and assemblages	Laying underground network pipes, installing chillers and building cooling plant.
Cooling activities	Operating and maintaining chillers and the cooling plant; and people's temperature and timing settings.
End-of-life	Decommissioning of cooling plants and distribution network.



EXAMPLES OF PASSIVE TECHNOLOGIES

Stages of cooling	**Plants in and surrounding buildings for shading and providing cooling**[63].
Resources	Seeds/cuttings, soil, nutrients and water.
Production and assemblages	Planting vegetation in adequate location and orientation to shield heat (for example, next to windows/ tree canopies on walls).
Cooling activities	Maintaining the vegetation in indoor and outdoor environments with support of the building administration (for example, pruning).
End-of-life	Removal of vegetation for building refurbishment purposes; or sustainable disposal of vegetation (for example, biomass for heat).



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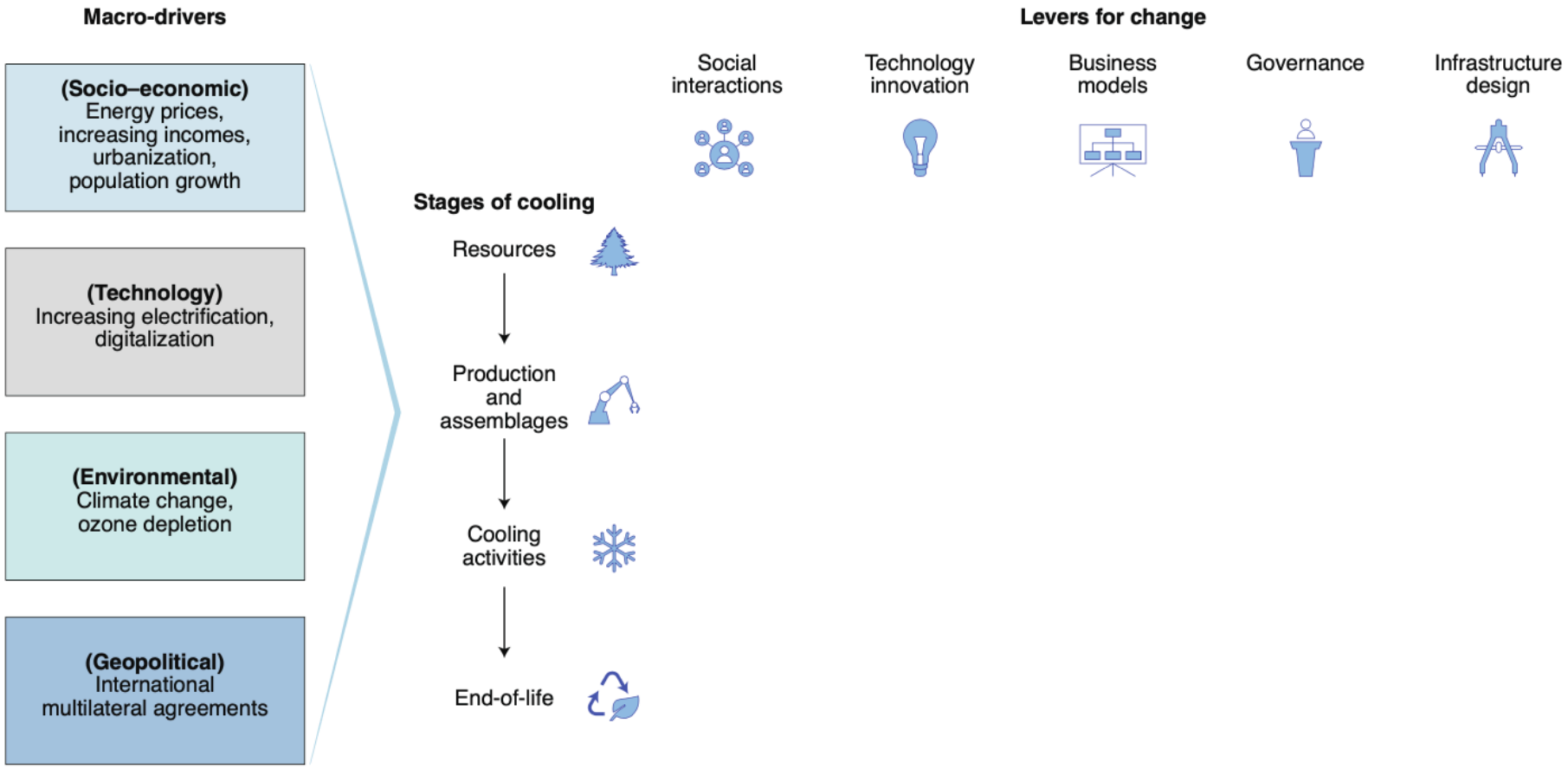

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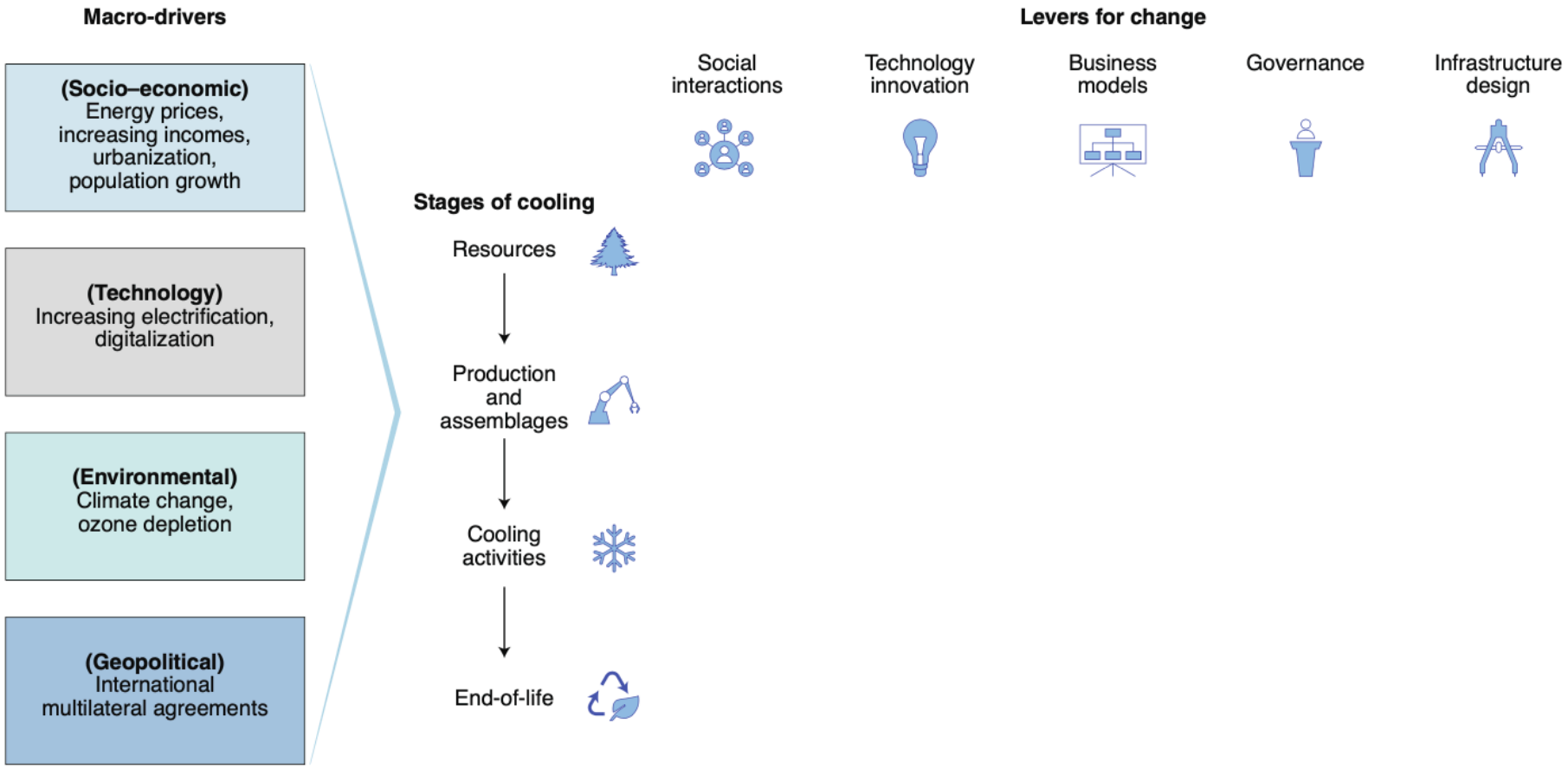
Picture taken by Dr Antonella Mazzone



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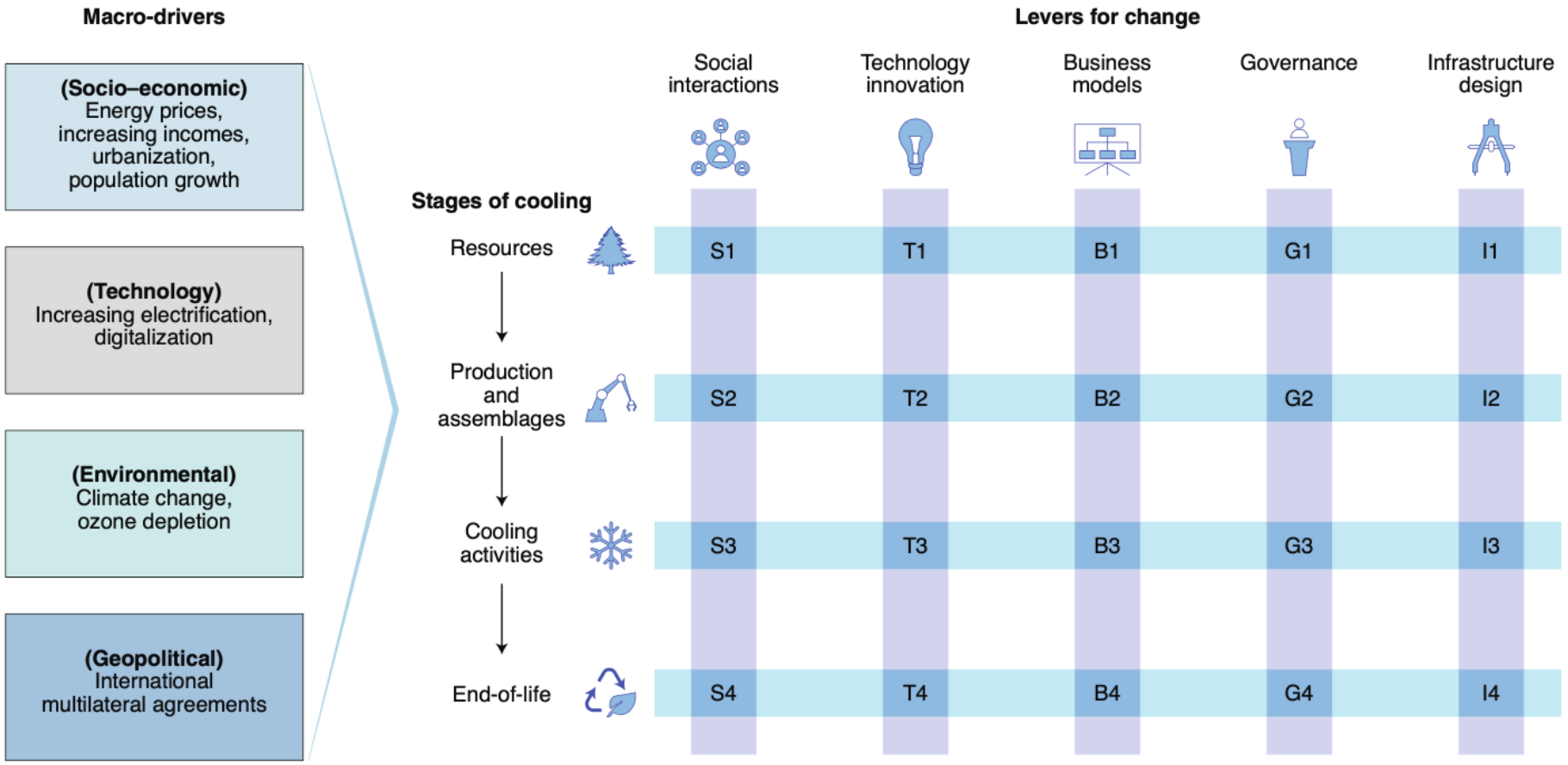

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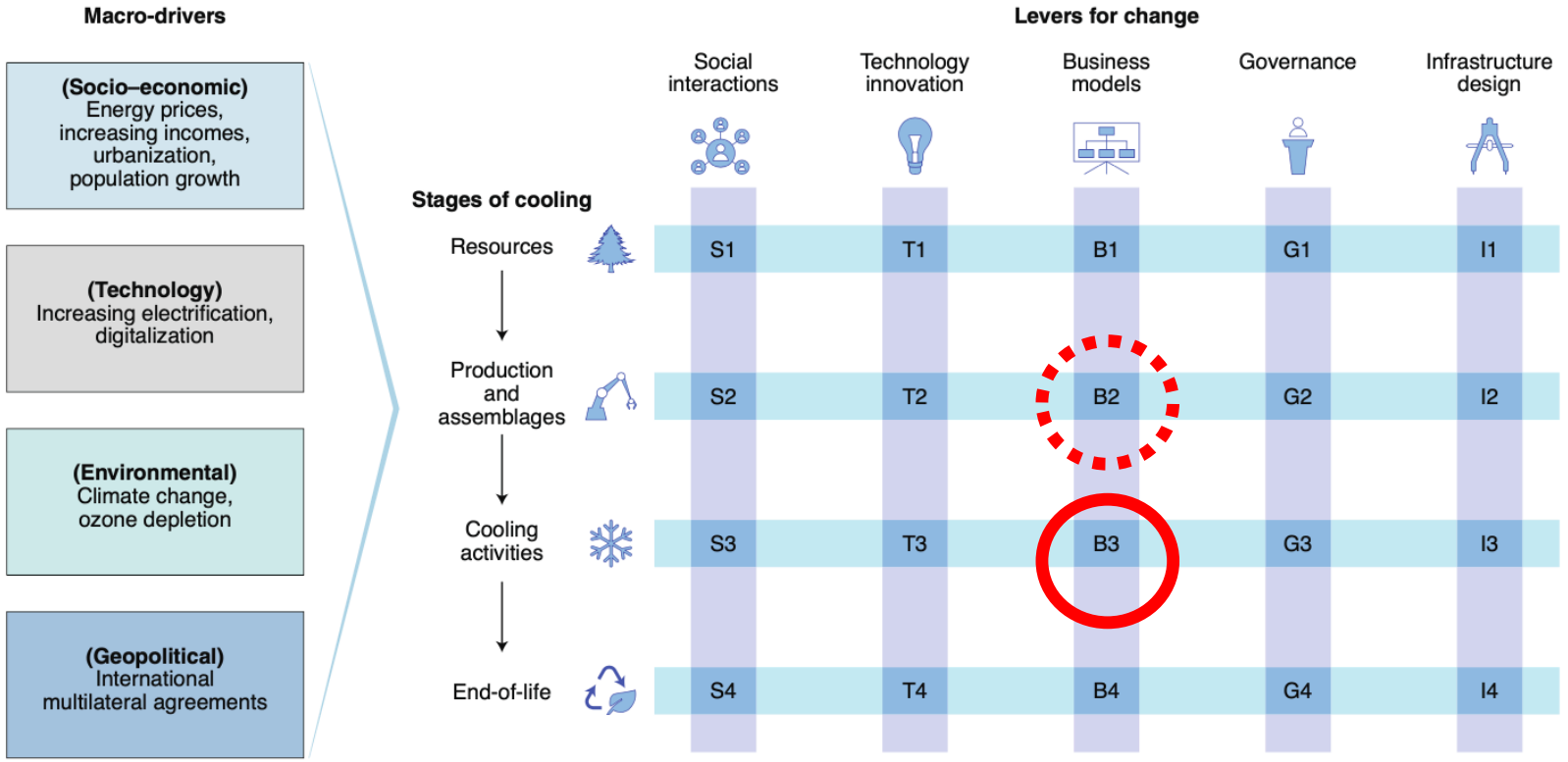
EXEMPLARY INTERVENTION POINTS

1. COOLING AS A SERVICE (CAAS)



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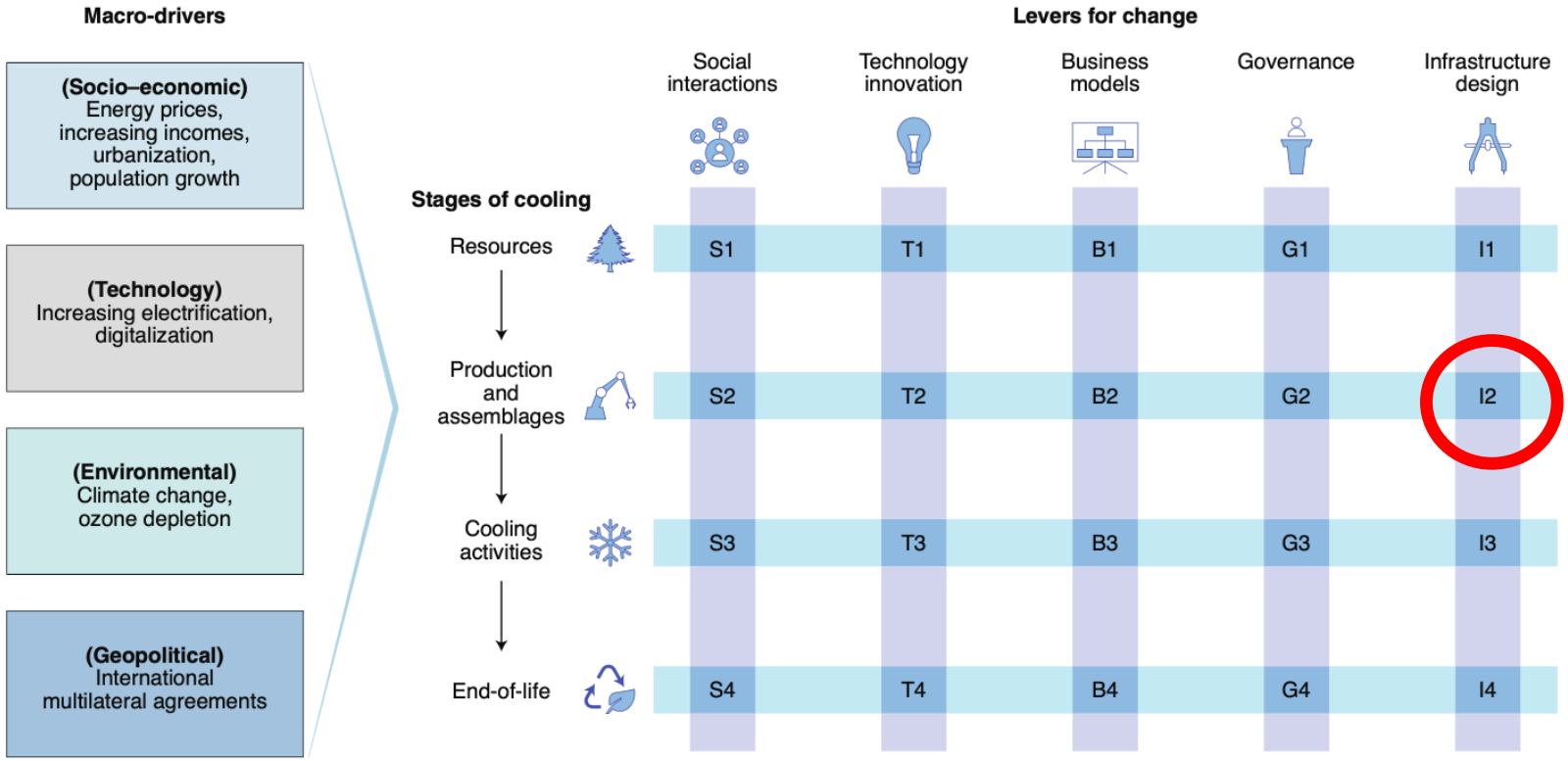
1. COOLING AS A SERVICE (CAAS)

- Value proposition: to make sustainable and more environmentally-friendly cooling broadly available.
- End-user avoids installation expenses and pays “as-you-go” for cooling.
- Company retains the cooling assets and operate them.

2. EMBEDDING PASSIVE & ENERGY EFFICIENT COOLING IN CITIES



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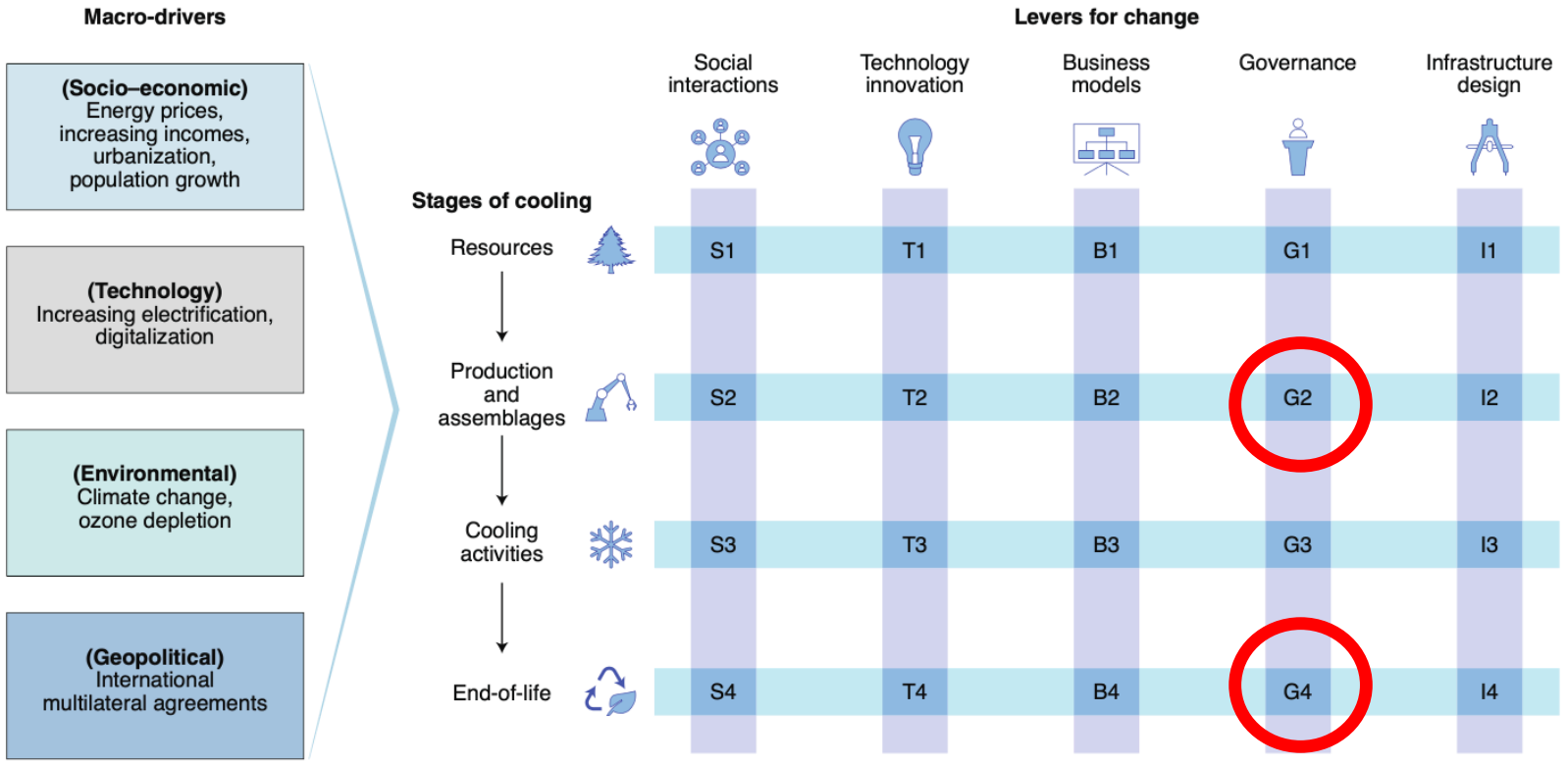
2. EMBEDDING PASSIVE & ENERGY EFFICIENT COOLING IN CITIES

- Cities is where cooling demand is/will surge.
- Passive technologies have longer life-span than components of active cooling.
- Require coordination of professionals, organizations with high-cooling demand and individuals.

3. LINKING TO CLIMATE ACTION AND GLOBAL PHASE-DOWN OF F-GASES



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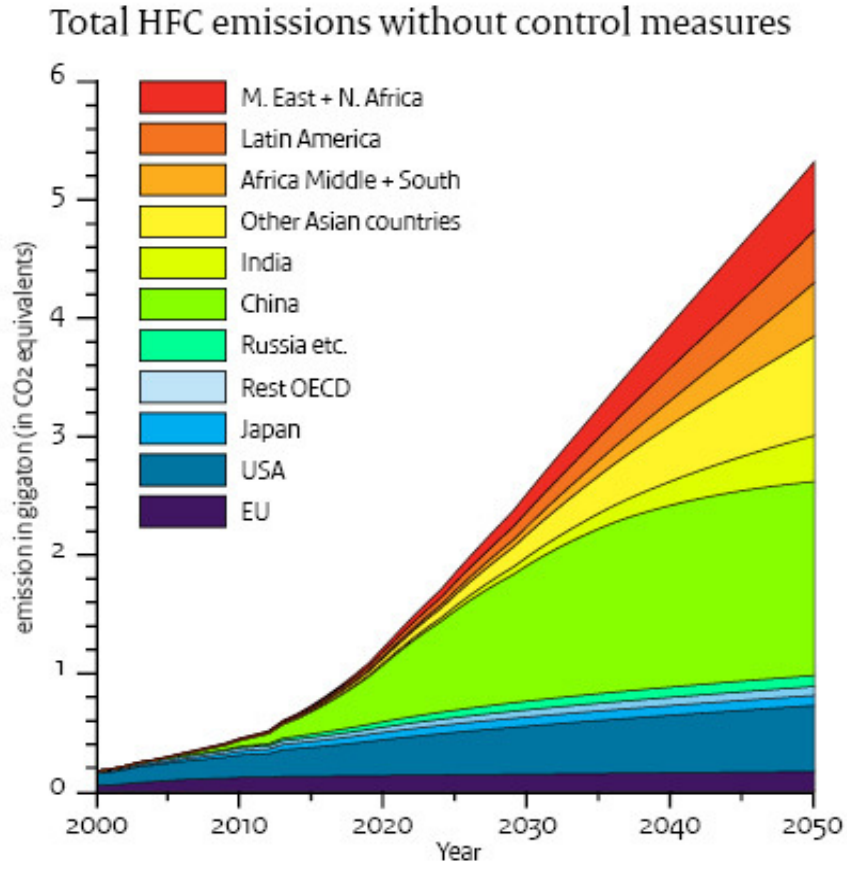
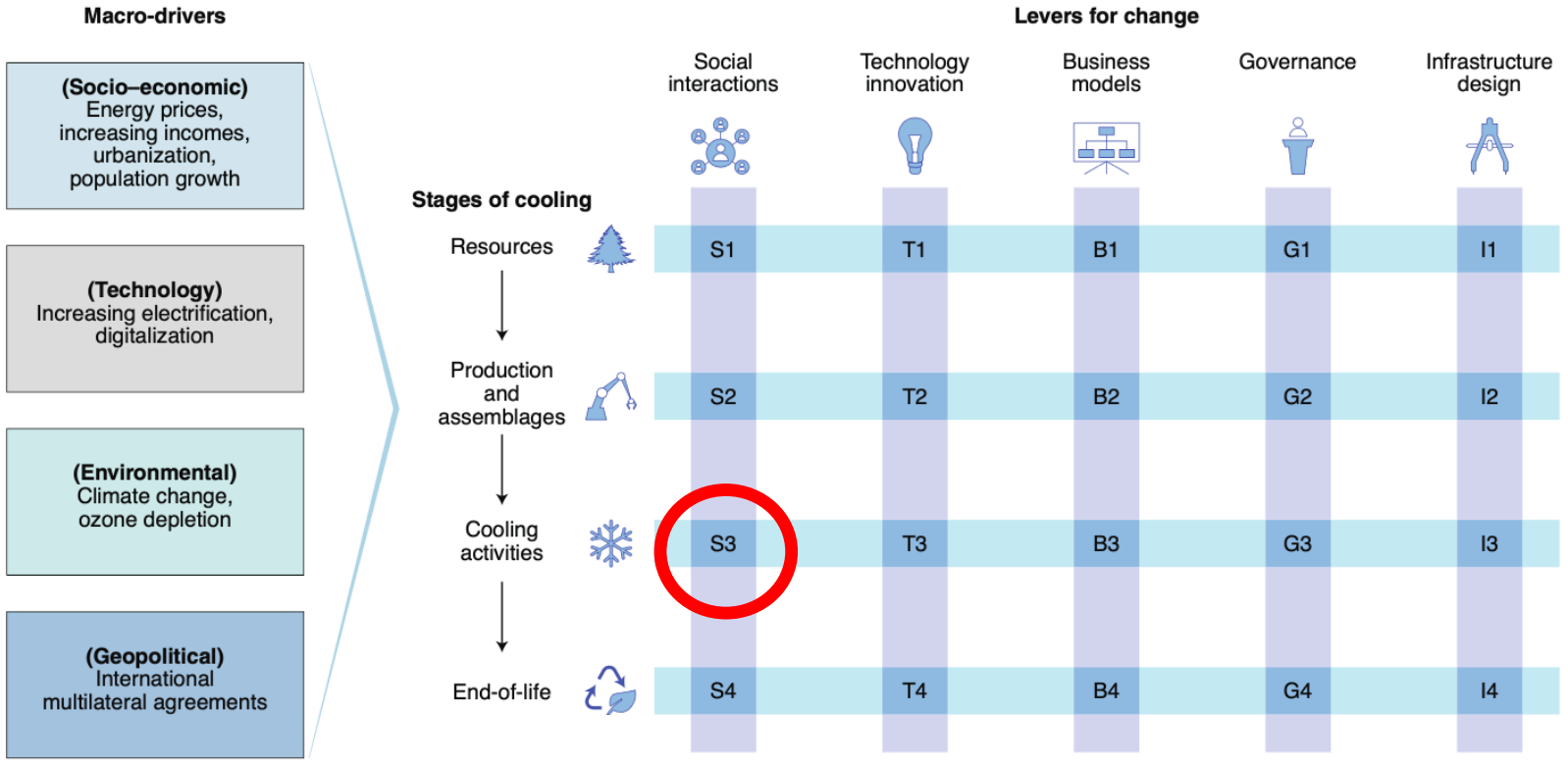
3. LINKING TO CLIMATE ACTION AND GLOBAL PHASE-DOWN OF F-GASES

- Refrigerants – some are 10,000x worse than CO_2
- Current trajectory would mean refrigerants are responsible for 20% of GHG emissions by 2050.
- Montreal Protocol and Kigali amendment has set targets.



4. ROLE OF LIFESTYLE AND BEHAVIOURS



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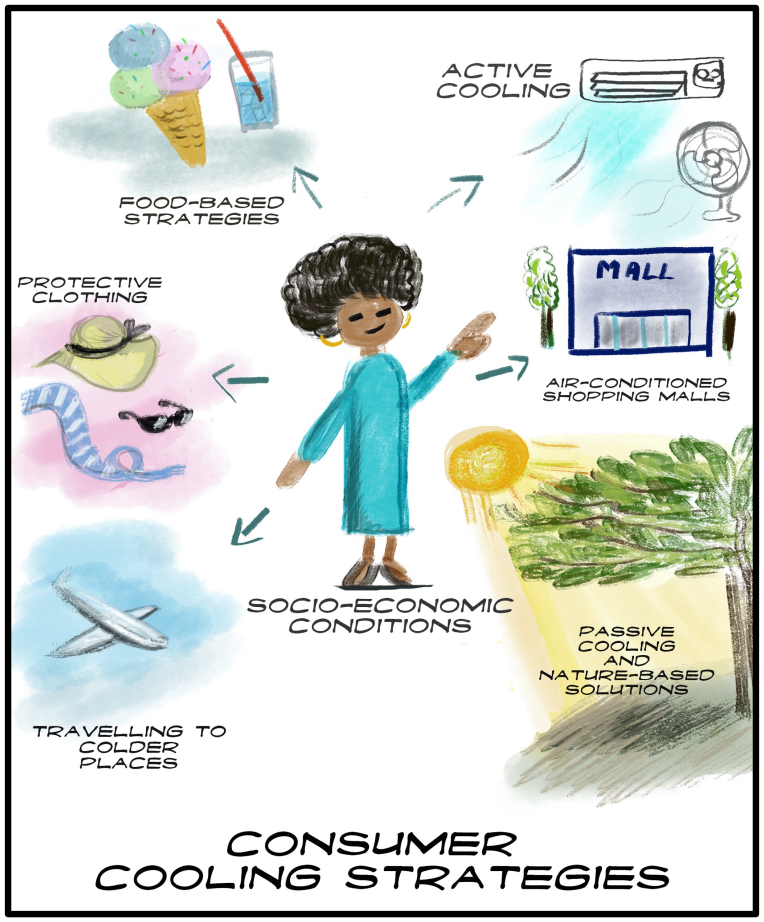


Artwork by Dr. Antonella Mazzone

- Lifestyle changes – e.g. using alternatives to active cooling
- Altering habits – e.g. changing thermostat set-points for ACs.
- Socio-cultural & psychological factors that can affect cooling demand.
- Behavioral and environmental psychology to play a role.

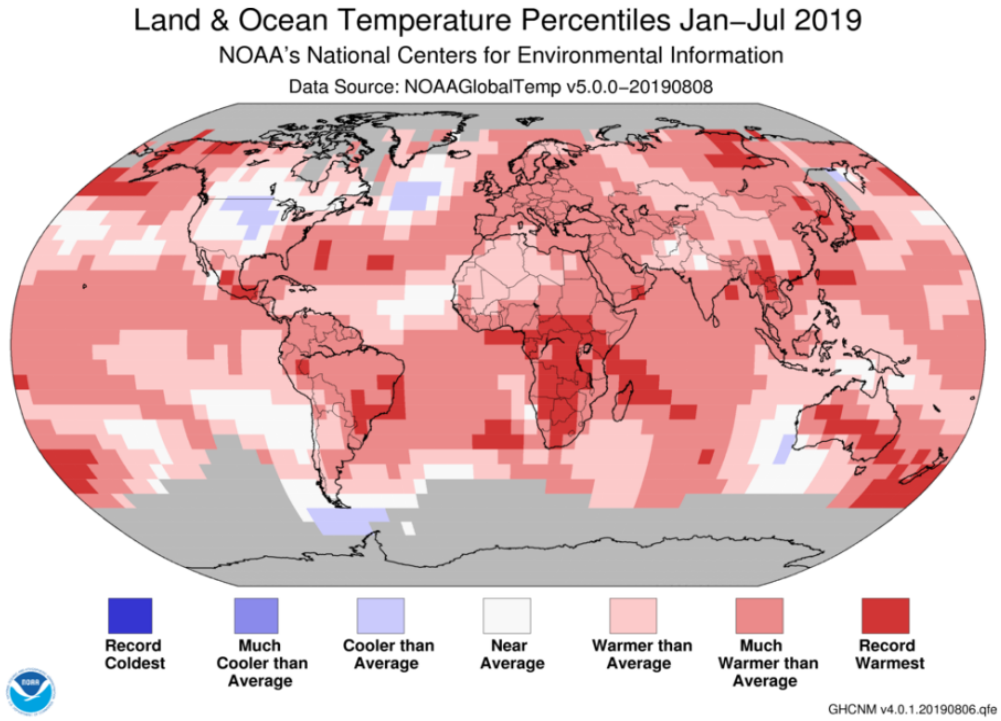
AGENDA FOR COOLING RESEARCH AND PRACTICE

I. PLACE PLANETARY STEWARDSHIP AND PROTECTING PEOPLE'S NEEDS AT THE HEART OF COOLING DECISIONS.

Motivation

Implication

II. PREPARE FOR AND MITIGATE CLIMATE CHANGE IMPACTS WHICH WILL DEMAND COOLING IN VARIED GEOGRAPHIES



Source: NOAA

Motivation

Implication

III. PROMOTE LONG-TERM SUSTAINABLE COOLING SOLUTIONS OVER EXISTING UNSUSTAINABLE BUSINESS-AS-USUAL ALTERNATIVES

Example of cooling technologies in Manilla, Philippines, 2018

Motivation

Implication

Three principles for sustainable cooling

I. PLACE **PLANETARY STEWARDSHIP AND PROTECTING PEOPLE'S NEEDS** AT THE HEART OF COOLING DECISIONS.

II. **PREPARE** FOR AND MITIGATE CLIMATE CHANGE IMPACTS WHICH WILL DEMAND COOLING IN VARIED GEOGRAPHIES

III. **PROMOTE** LONG-TERM SUSTAINABLE COOLING SOLUTIONS OVER EXISTING UNSUSTAINABLE BUSINESS-AS-USUAL ALTERNATIVES

OUR TEAM AND PROGRAMME

THE TEAM

OXFORD MARTIN SCHOOL

UNIVERSITY OF OXFORD

RADHIKA KHOSLA
Geography

MALCOLM MCCULLOCH
Engineering

RAFAEL PERERA
Primary Care

CAITLIN MCELROY
Geography

FRANCOIS COHEN
Geography

RENALDI RENALDI
Engineering

ANANT JANI
Primary Care

PHILIPP TROTTER
Geography

ANTONELLA MAZZONE
Geography

NICOLE MIRANDA
Engineering

OUR RESEARCH QUESTION

- How do we *understand* and *shape* the unprecedented future growth in global cooling demand to deliver on the Sustainable Development Goals?

Thank you!

For more information visit

https://www.oxfordmartin.ox.ac.uk/future-of-cooling

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