

Typology of pathways for sustainable transformation

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Outline

1. Motivation
2. Literature
3. Methodology
 - 3.1. Choices
 - 3.2. Interpretation
4. Results
5. Application
6. Discussion

1. Motivation | need for systematic guidance

Climate stabilization (1.5°C) requires **immediate action, but it is unclear** what are the main strategies that actors and policymakers can pursue.

There is a need to understand the different types of **strategies for decarbonization (or pathways)**.

Each pathway is expected to have **different requirements and benefits**.

Is it possible to construct a typology of mitigation strategies?

Can we infer such typology **from the literature?**

2. Literature | some approaches

Generic mitigation approaches:

- Vertical, CO₂ taxation (NORDHAUS 2019)
- Horizontal, missions (MAZZUCATO 2019)

Potential futures, but no strategies:

- IPCC's SSPs (shared socioeconomic pathways) (RIAHI et al 2017)
- Narratives (SKEA et al 2021)

Highly **aggregate** analysis:

- 3 broad strategies (SACHS et al 2009)
 - **"decarbonization of electricity generation"**
 - **"energy efficiency in final energy use"**
 - **"electrification of current **uses** of fossil fuels"**
- Disciplines in the literature (CALLAGHAN et al 2020)

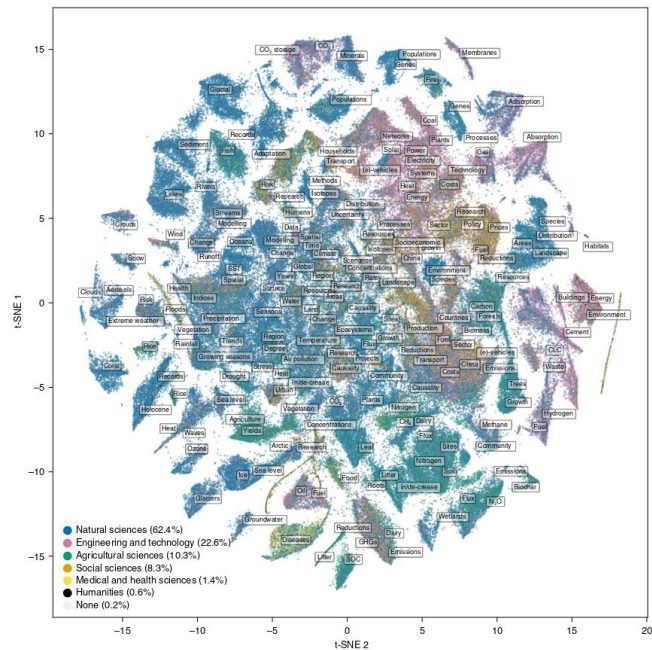


Fig 1: "A map of the literature on climate change"

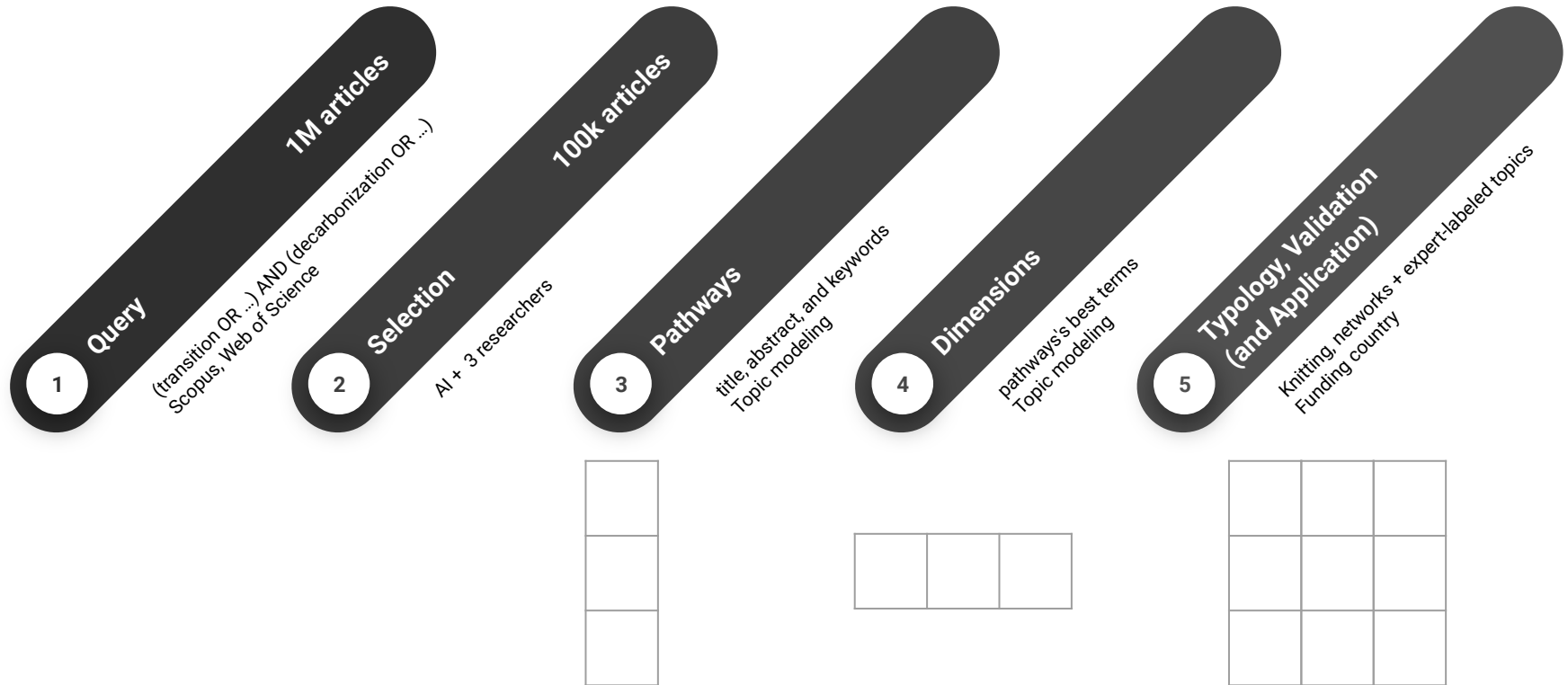
Callaghan, M. W., Minx, J. C., & Forster, P. M. (2020). A topography of climate change research. *Nature Climate Change*, 10(2), 118-123.



Fig 4: Visual representation of articles, each a dot

3. Methodology | overview

Fig 3: Approach process



3. Methodology | detailed

Literature selection:

- ASReview (VANDESCHOOT et al 2021)

Natural language processing:

- LDA (BLEI et al 2001)
- UMAP (MCINNES et al 2020)
- sBERT (REIMERS et al 2019)
- BERTopic (GROOTENDORST 2022)

Co-citation analysis:

- Agglomerative, bottom up (PEIXOTO 2014)

Interpretation:

- Tea leaves (CHANG et al 2009)

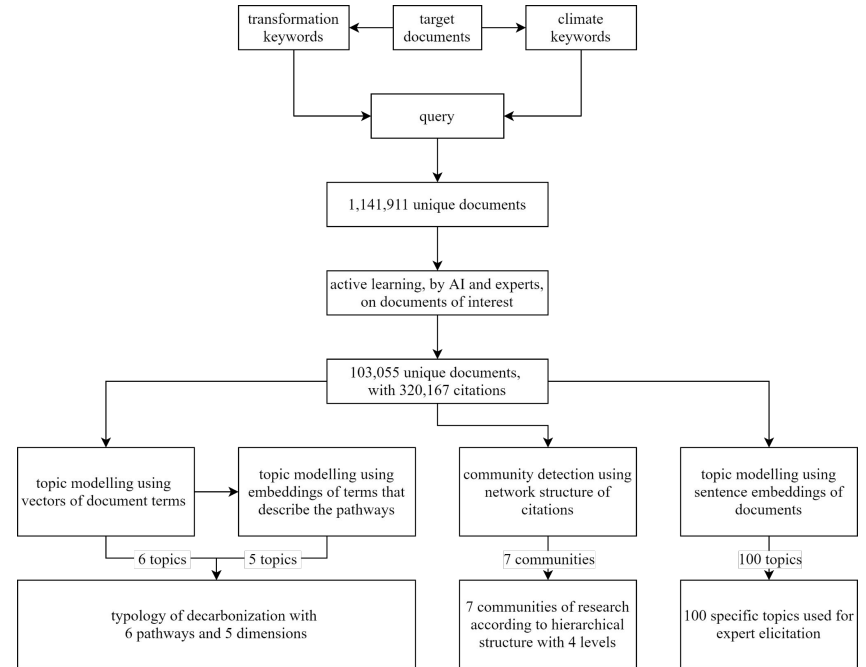


Fig 4: Detailed approach

1.1. Methodology | choices

- Query
- Literature selection
- Preprocessing
- Hyperparameter tuning
- Number of pathways and dimensions
- (In)frequent term rejection

```
TITLE-ABS-KEY (
    (pathway* OR transition* OR
    strateg* OR scenario* OR roadmap* OR
    plan* OR goal* OR outlook* OR narrative* OR
    mitigation OR adapt*)
    AND
    (climate OR (energy AND (suppl*
    OR demand* OR global ) ) OR carbon OR
    warming OR emission* OR sustain*))
    AND LANGUAGE ( english )
    AND DOCTYPE ( "ar" )
    AND PUBYEAR > 2010
```

Fig 5: Query used

(a) Probability of articles being of interest

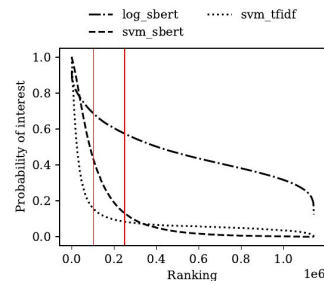


Fig 6: Literature selection

(b) Article picks in common across models

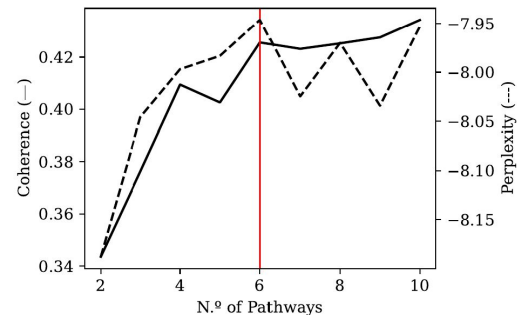
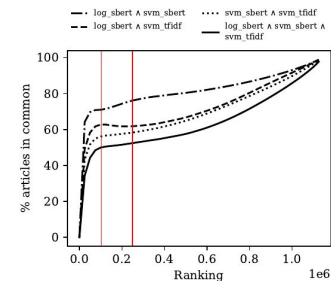


Fig 7: Pathways selection

1.2. Methodology | typology interpretation

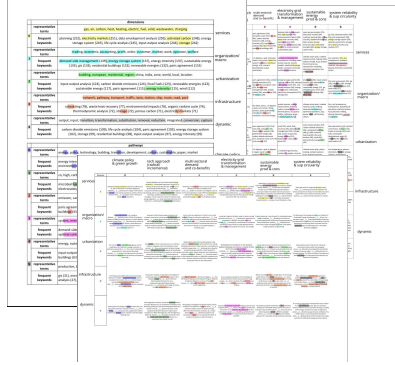


Fig 8: frequent and representative terms and keywords

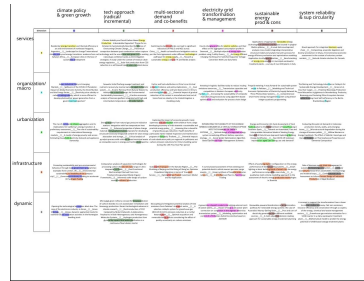


Fig 9: Representative titles

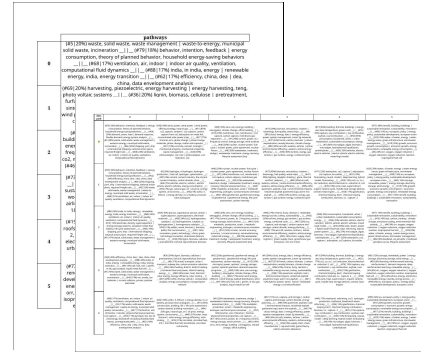


Fig 10: expert topic's terms and keywords

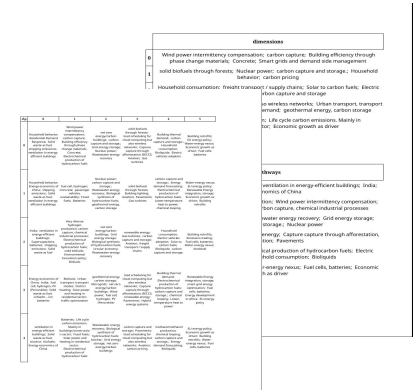
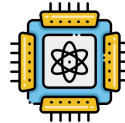


Fig 11: expert topic's description

4. Results | 6 decarbonization strategies



Integrated systems



Technology breakthrough



Demand & co-benefits



Decarbonization of electricity



Electrification of uses



Land use and circularity

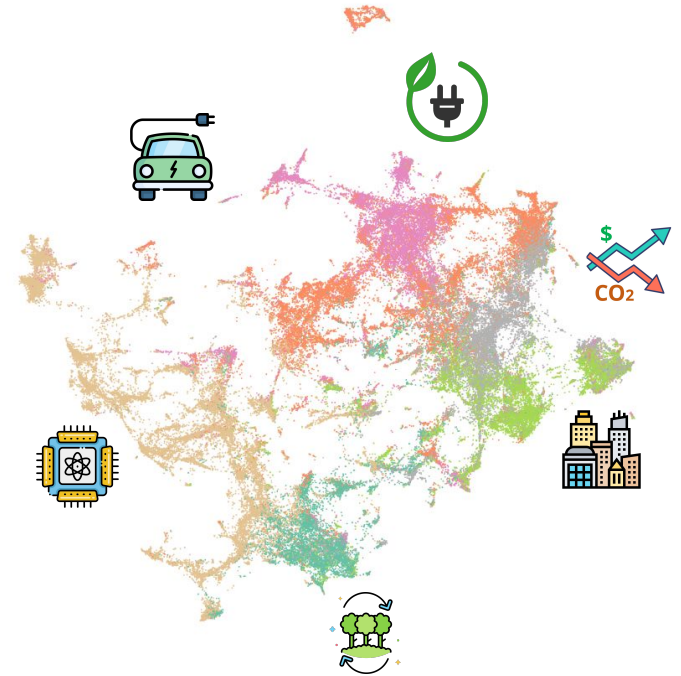
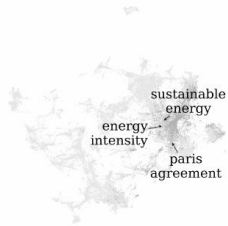


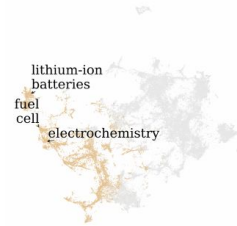
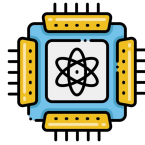
Fig 12: Pathways in the typology

4. Results | key topics by strategy

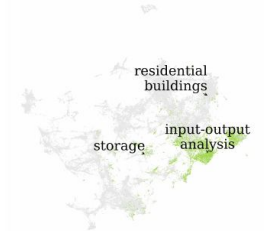
(a) Integrated systems



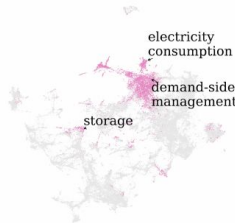
(b) Technology breakthrough



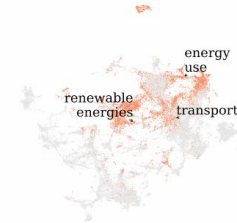
(c) Demand and co-benefits



(d) Decarbonization of the electricity



(e) Electrification of uses



(f) Land use and circularity

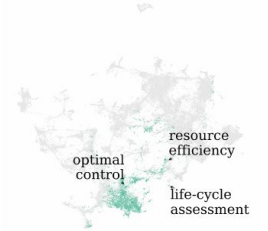


Fig 13: Selected keywords per pathway

4. Results | dimensions across the strategies

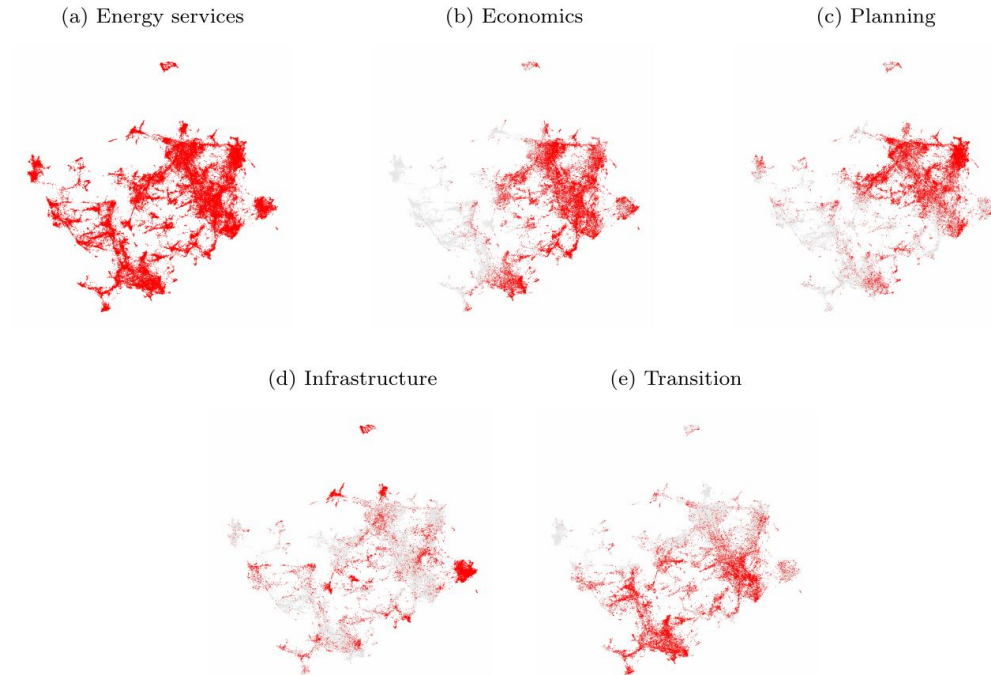
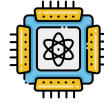


Fig 14: Dimensions of the typology

4. Results | themes at the intersection



Pathways Dimension	Integrated Systems	Technology Breakthrough	Demand & Co-benefits	Decarbonization of Electricity	Electrification of Uses	Land Use & Circularity
Energy Services	Integration of various technologies and policy measures	Advancing and deploying innovative technologies	Multi-sectorial energy demand and co-benefits (e.g. air quality)	Transition from fossil fuel-based power generation to low-carbon sources	Replacement of fossil fuel-based energy sources with electricity in end uses	Combating deforestation and soil degradation
Economics	Macroeconomic assessments and multisectoral optimization	Costs and benefits of deploying innovative technologies	Balancing demand reduction with co-benefits	Costs and benefits of transitioning to low-carbon power sources	Costs and benefits of electrification of end uses	Resource use efficiency and circular economy principles
Planning	Policy measures and regulatory frameworks	Innovation planning and regulations	Behavioral change and technology adoption	Flexible and resilient electricity grid	Policies to promote electrification of end uses	Policies to combat deforestation and soil degradation
Infrastructure	Multisectoral energy system transformation	Deployment of innovative technologies	Infrastructure to support demand reduction	Renewable energy sources and storage technologies	Electric vehicle infrastructure and charging networks	Sustainable land management and circular economy systems
Transition	Transitioning from high-carbon to low-carbon economy	Adoption of innovative technologies for deep decarbonization	Combining technology responses with behavioral change	Transition from high-carbon power generation to low-carbon sources	Transition from high-carbon energy sources to electrification	Transition to sustainable land use and resource management

Fig 15: Detailed description of the decarbonization strategies by dimensions

5. Application | change in countries's strategies, via proxy

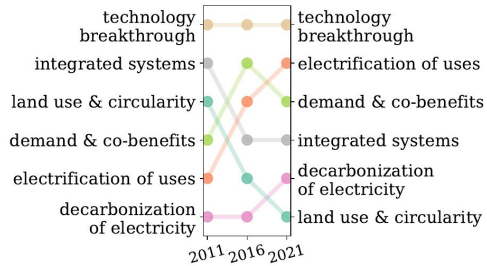


Fig 16: United States

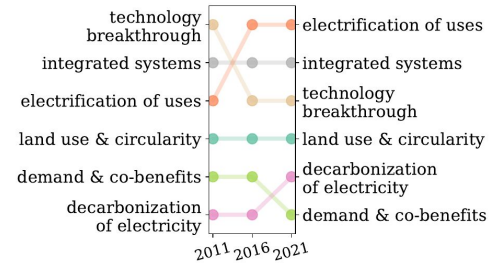
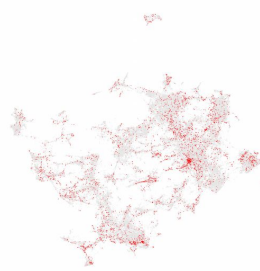


Fig 17: European Union

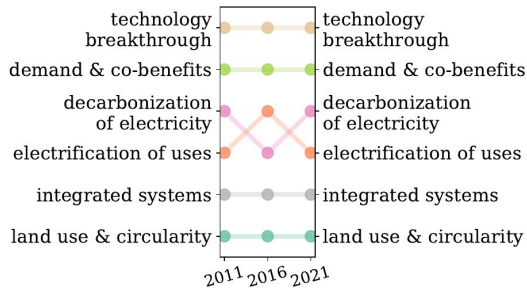
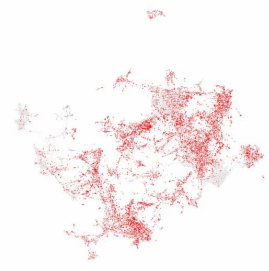


Fig 18: China

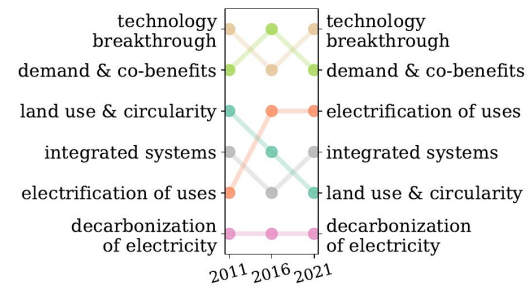
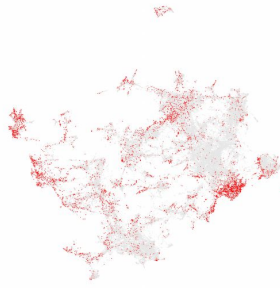
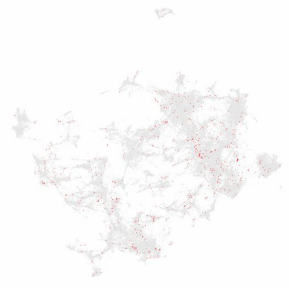


Fig 19: Japan



6. Discussion | some contributions

Taxonomy of strategies identified:

- more **complete** number of strategies
- **detailed representation** of strategies

Country analysis show **heterogeneity** in mitigation:

- differences among countries
- stability of strategies within countries over time

There are **limitations**. E.g.: data access and topic quality assessment.

Further work and applications:

- understanding strategy mixes
- ongoing strategy evaluation in different domains (i.e. technology, geography, policy)

Thank you