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Decoding Circular Economy Research: A Bibliometric and Topic Analysis

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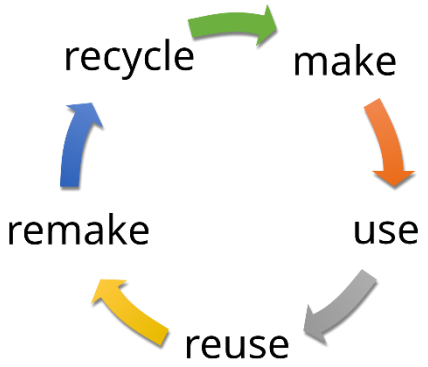
Introduction

Introduction

- **Circular Economy (CE):**
  - *A model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible* (European Parliament, 2023)
  - Seeks to close material loops through **reuse**, **recycling**, and **regeneration**
  - Influences policies, business models, and technological innovations!

- **Research on CE** has gained significant momentum globally, with institutions around the world exploring its applications.



Introduction

- **Aim of our work**: To provide an understanding of the CE research spectrum through a comprehensive bibliometric analysis

- How?
  - By analyzing the metadata and abstracts from **16,424 research articles** which are **highly-related to CE**, published over a **20-year period (2004–2024)**

- Why?
  - Map **publication trends** over time
  - Reveal key **contributors** (subject areas, journals, publishers, countries, collaborations)
  - Uncover **main themes** and **focus**
  - Support informed action with an **evidence-based overview**

Related work

Bibliometric studies examining CE research trends:

- Ruiz-Real et al. (2018):
  - 743 publications from the Web of Science
- Camón Luis and Celma (2020)
  - 3391 publications from the Web of Science and 1901 from Scopus
- Alnajem et al. (2021)
  - 214 CE publications gathered from the Web of Science
- Goyal et al. (2021)
  - 33 highly cited articles + 10 recent articles (for identifying future research directions)

- Difference of our approach:
  - our analysis is based on a **significantly larger dataset** (16,424 articles), more than 60% of which have been published after 2021
  - our analysis is **fully automated**, **exploiting the full dataset** (not only a small set of top-cited works)

Methodology

Data Collection

- We searched the **Scopus database**
  - Query string **“circular economy”** (*inside double quotation marks*)
  - Fields: **article title** OR **keywords**
  - Years: **<=2024**

  (this selection ensures that all collected publications are strongly connected to CE)

Scopus®

- We ran the query on January 17, 2025

- The query returned 26,940 publications
  - Journal articles: 16,424, Conference papers: 4,021, Reviews: 3,24, Book chapters: 2,383

We have considered only the **16,424 publications** of type “**Article**”, focusing on only high-quality, full research papers

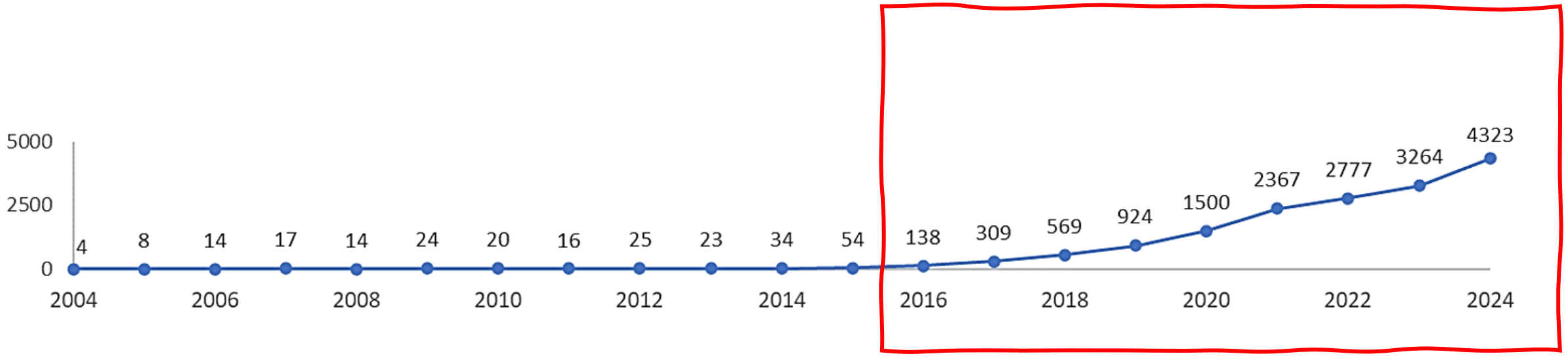
Analysis dimensions

- Metadata analysis
  - publication years
  - subject areas
  - journals and publishers
  - author countries
  - author collaborations across countries

- Content analysis:
  - Author keywords
  - RE-words: words starting with 're’ in the title and keywords, connected to main pillars of CE [Circular Asia Association 2023, https://www.circulareconomyasia.org/circular-rs/]
  - Topics / themes

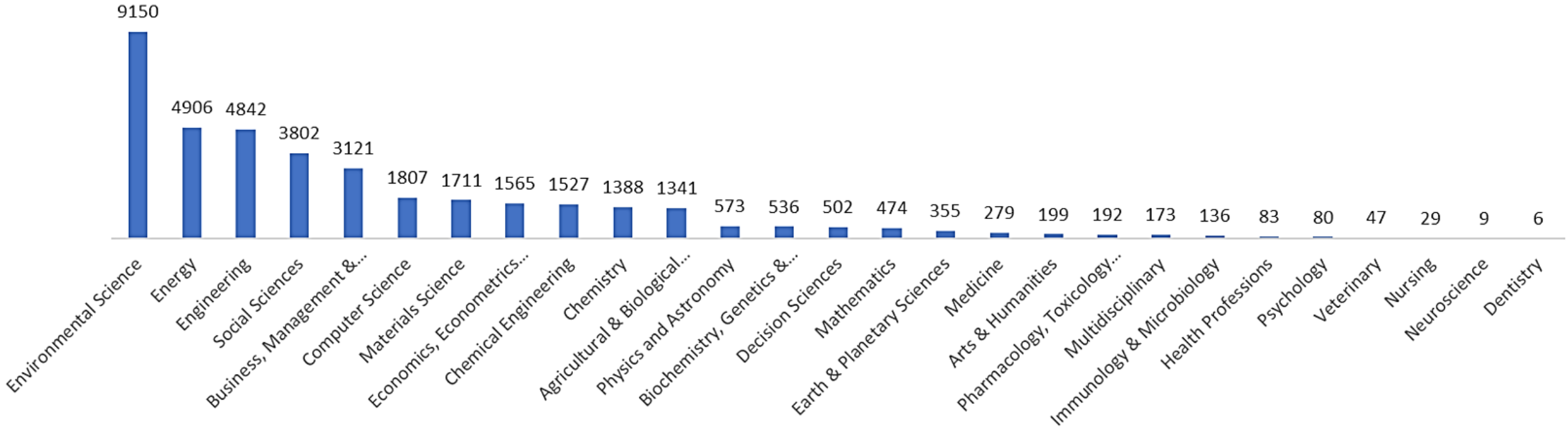
Results

Publication Years



- A significant increase occurred in 2016 (155.6% increase)
- In absolute numbers, the largest increase in articles occurred from **2023 to 2024**, with **1,059 additional publications**!
- This data highlights the significant growth in interest for CE research in recent years.

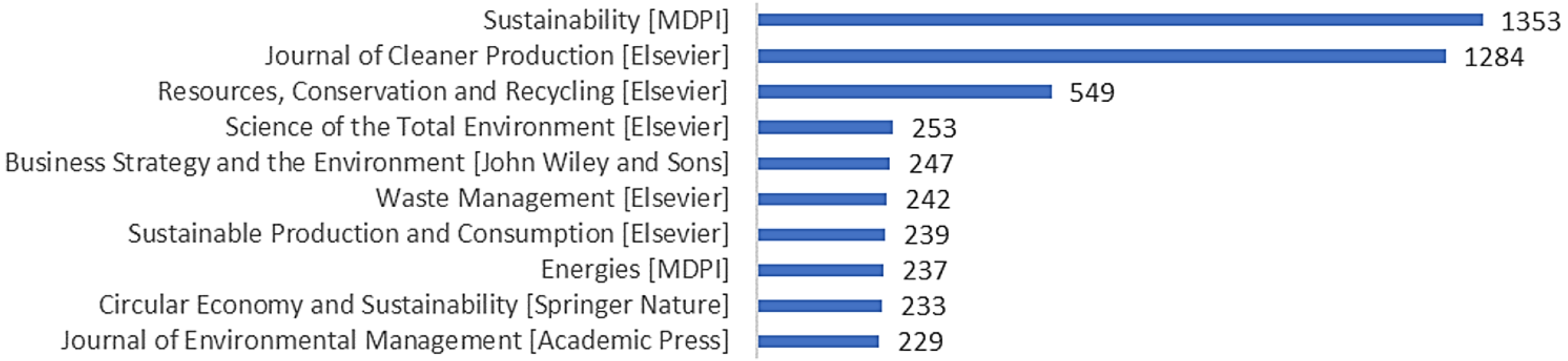
Subject Areas



- As expected, **Environmental Science** is the leading subject area (9,150 articles), followed by **Energy** (4,906 articles) and **Engineering** (4,842 articles).
- We notice that the CE concept is applied in a **large variety of subject areas**, including the Social Sciences, Computer Science, and Materials Science

Journals

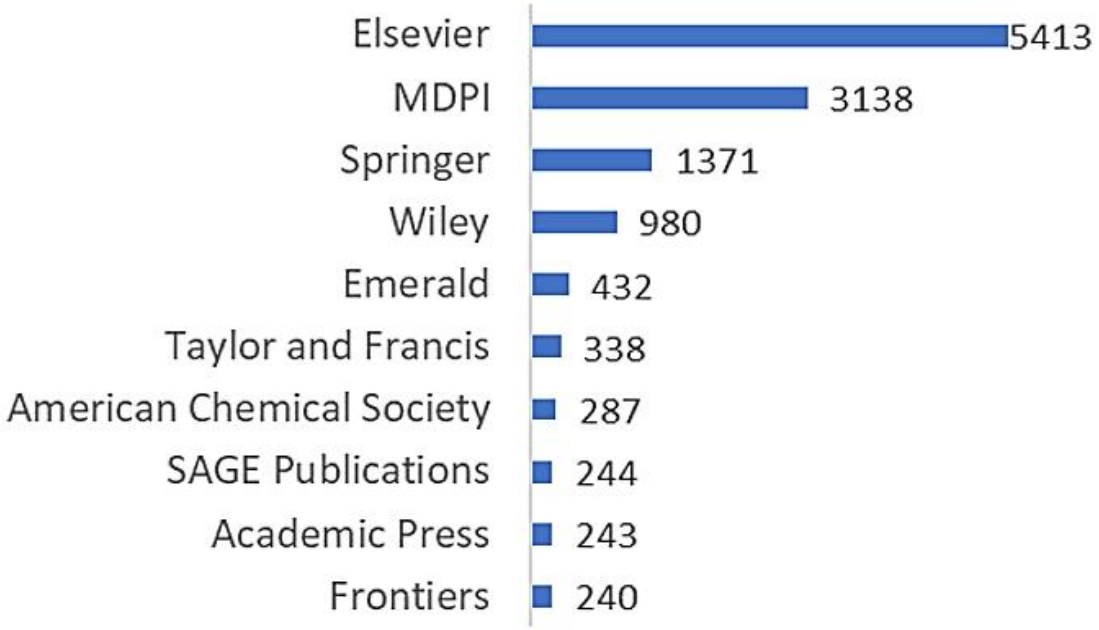
Top-10 journals with the highest number of CE articles



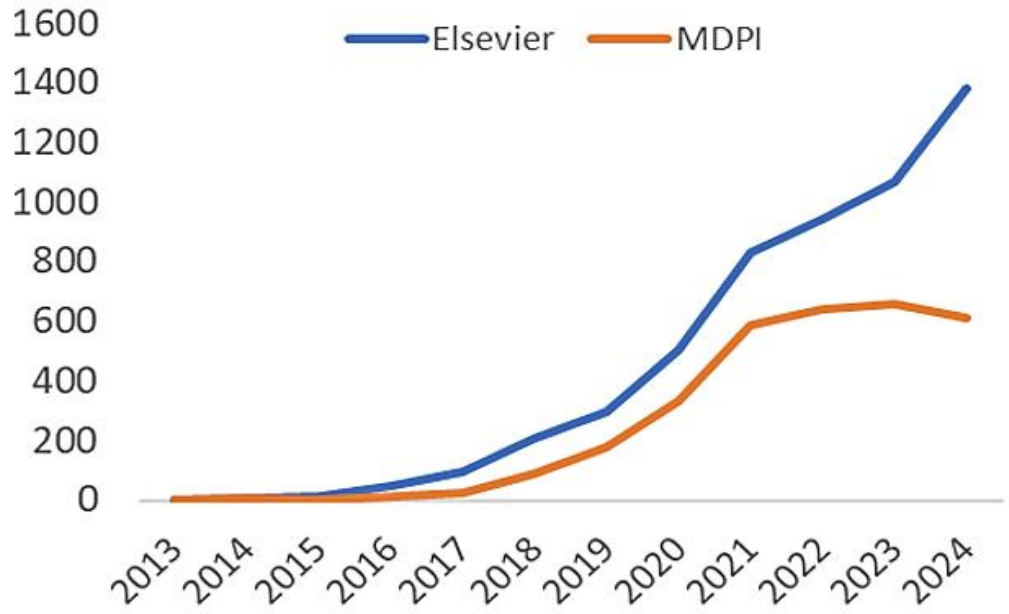
- The **MDPI** journal **Sustainability** is in the top position with 1,353 articles (8.2%), followed by the **Elsevier Journal of Cleaner Production** (7.8%)
- The first two journals published 16% of all CE articles

Publishers

Top-10 publishers



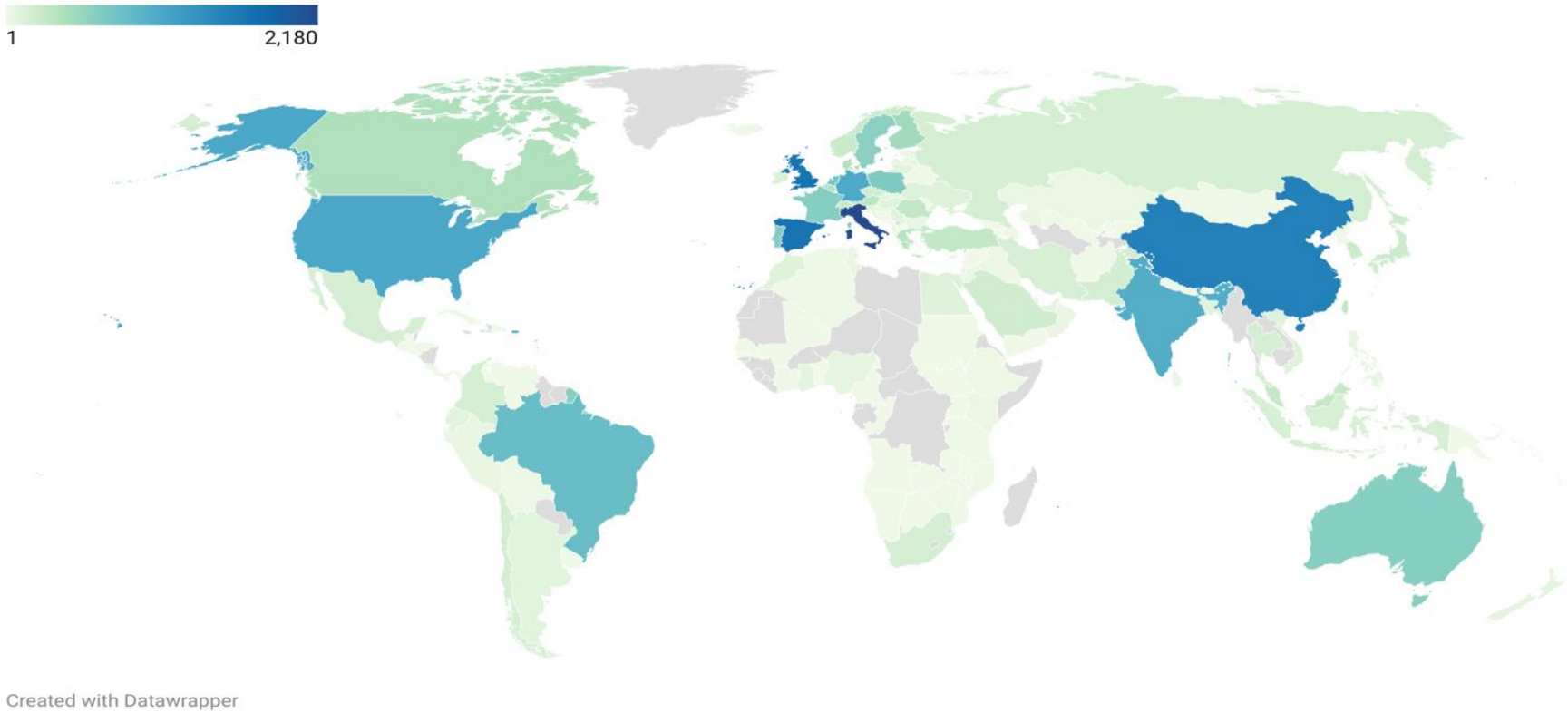
Number of CE articles per year



- **Elsevier** highly outnumbers the other publishers with 5,413 articles (**33%** of all CE articles)
- Second is **MDPI** with 3,138 articles (**19.1%**)

- Decline in the number of MDPI articles in 2024!

Author Countries



- The first country is **Italy** with 2,180 articles, followed by **Spain** (1,699), **UK** (1,690), **China** (1,542) and **USA** (1,089)

Author Countries (normalized)

- Normalized by country population

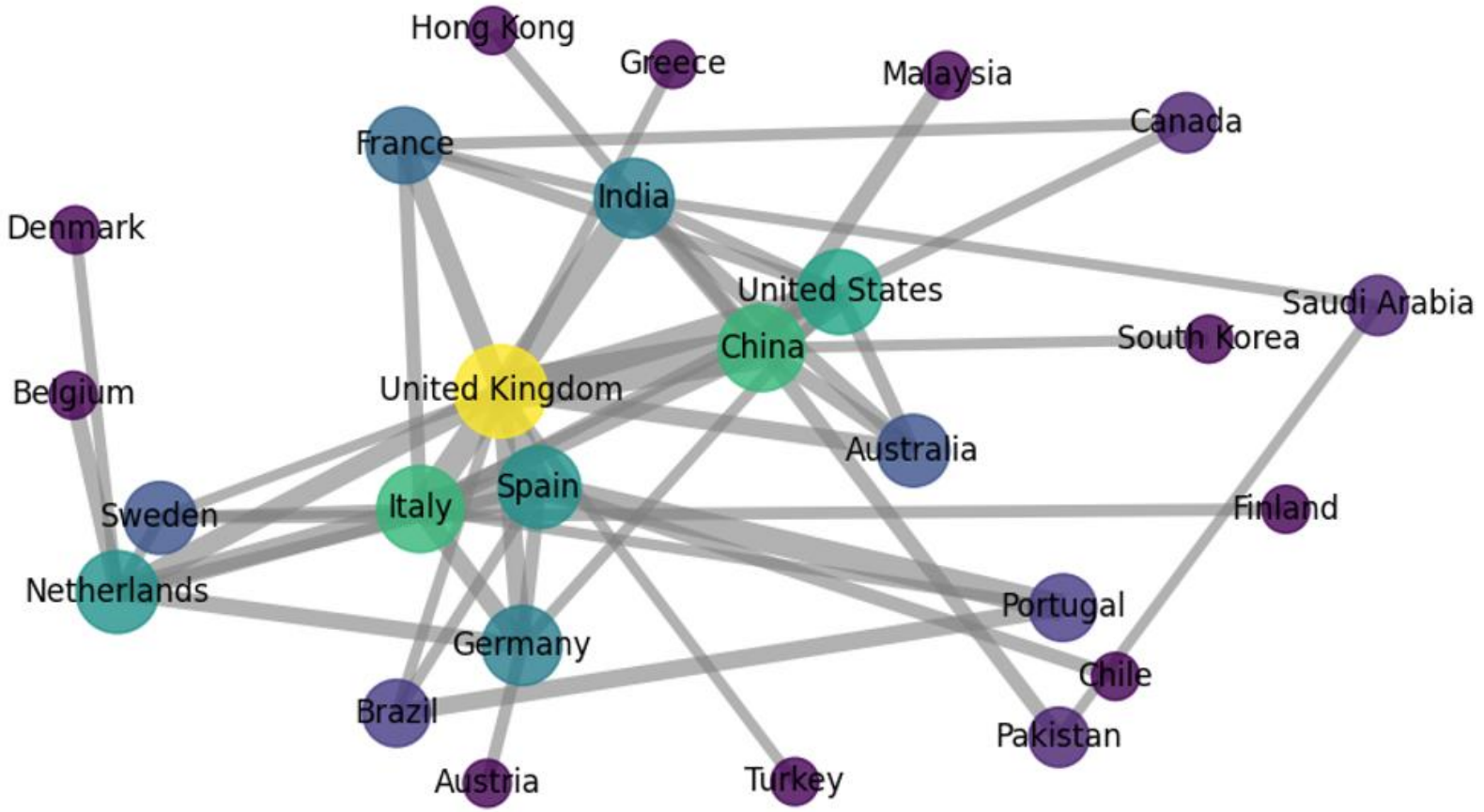
Top-20 countries based on the number of articles per one 1M of population

1	Finland	85.7	5 Cyprus	50.7	9 Slovenia	43.2	13 Austria	35.7	17 Estonia	33
2	Denmark	65.5	6 Luxembourg	48.4	10 Lithuania	39.4	14 Iceland	34.6	18 Latvia	30.3
3	Portugal	62.8	7 Netherlands	45.9	11 Italy	37	15 Belgium	33.6	19 Switzerland	29.4
4	Sweden	59.9	8 Norway	43.5	12 Spain	35.8	16 Greece	33.4	20 Brunei	28.3

- The ordering is now very different!
- **Finland** is first with 85.7 articles per 1M of population, followed by **Denmark** (65.5), **Portugal** (62.8) and **Sweden** (59.9)

Collaborations across countries

- Top country collaborations in CE articles



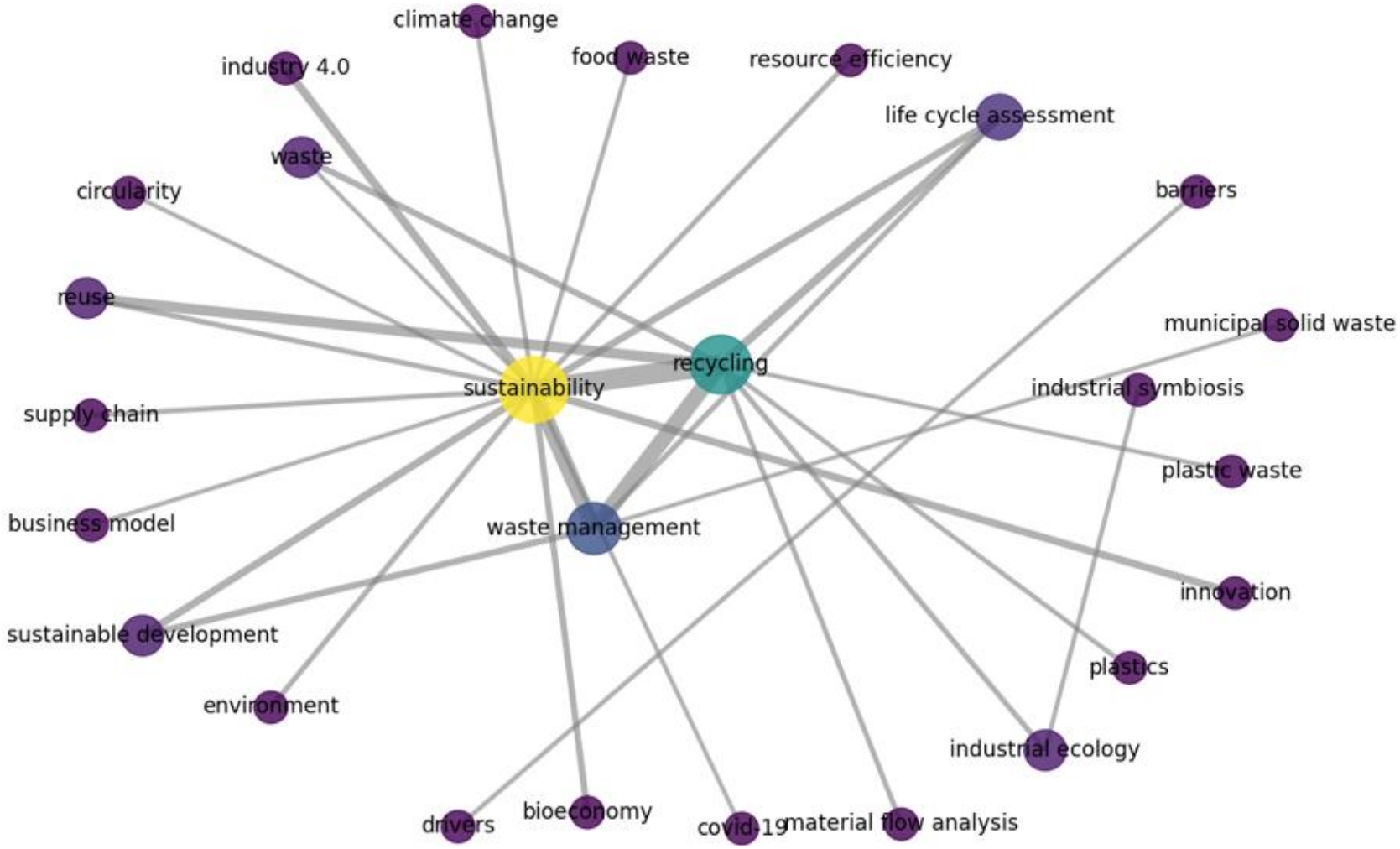
Top-3 collaborations

- China-UK (163 articles)
- Italy-Spain (143 articles)
- China-USA (133 articles)

- **UK** leads the top-20 list, partnering with 9 other countries
- **China** ranks second with collaborations with 6 other countries

Author Keywords (co-occurrences)

Top 30 pairs of co-occurring author keywords

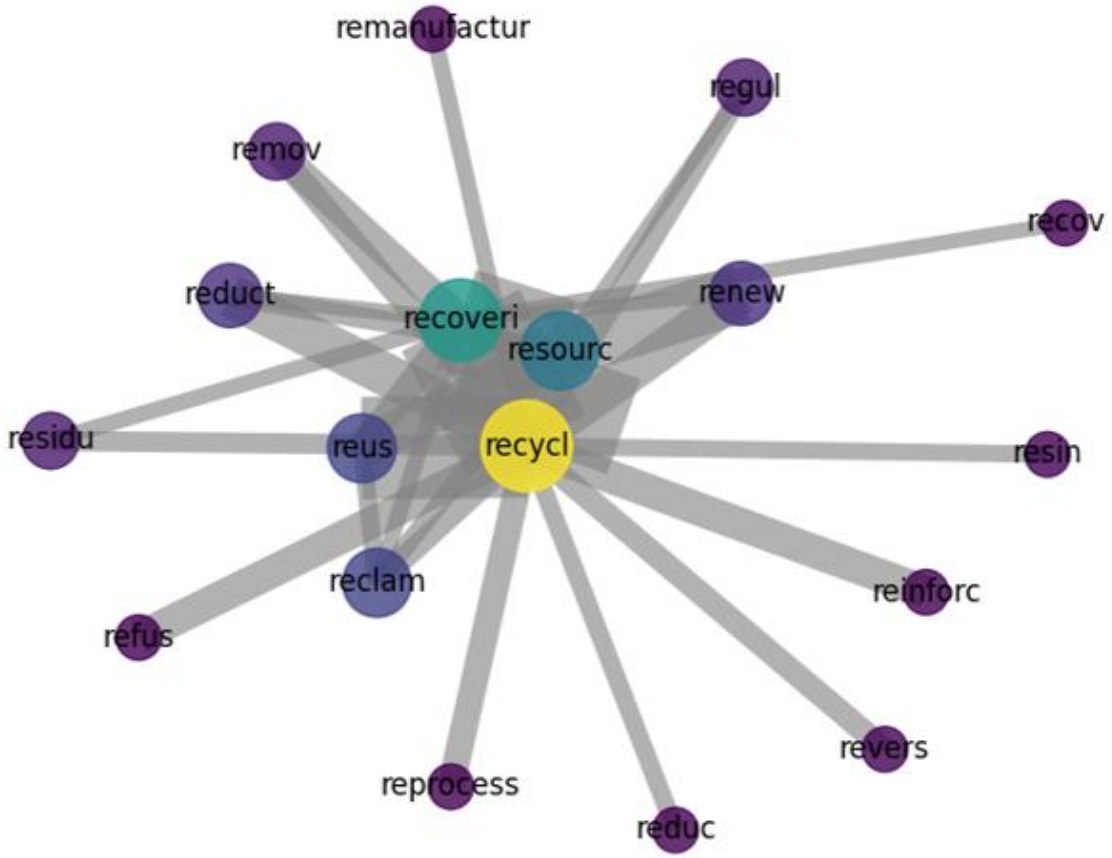


- We notice three core, connected keywords related to three important aspects of CE: **sustainability**, **recycling**, and **waste management**

- The remaining keywords in the network cover other important CE aspects including **life cycle assessment, industrial ecology, food waste, climate change, industry 4.0, supply chain, bioeconomy**

RE-s (co-occurrences in titles, abstracts and keywords)

Top-30 cooccurrences of RE-s



- We have applied **stemming** and considered the base/ root form of the words
- We notice three core RE-s, **recycle, resource, and recoveri**, followed by **reus**, **reclam**, **renew** and **reduct**, which are altogether highly interconnected
- Other frequent RE-s include **remanufactur**, **residu**, **regul**, **recov**, **resin, reinforc, revers, reduc**, and **reprocess**.

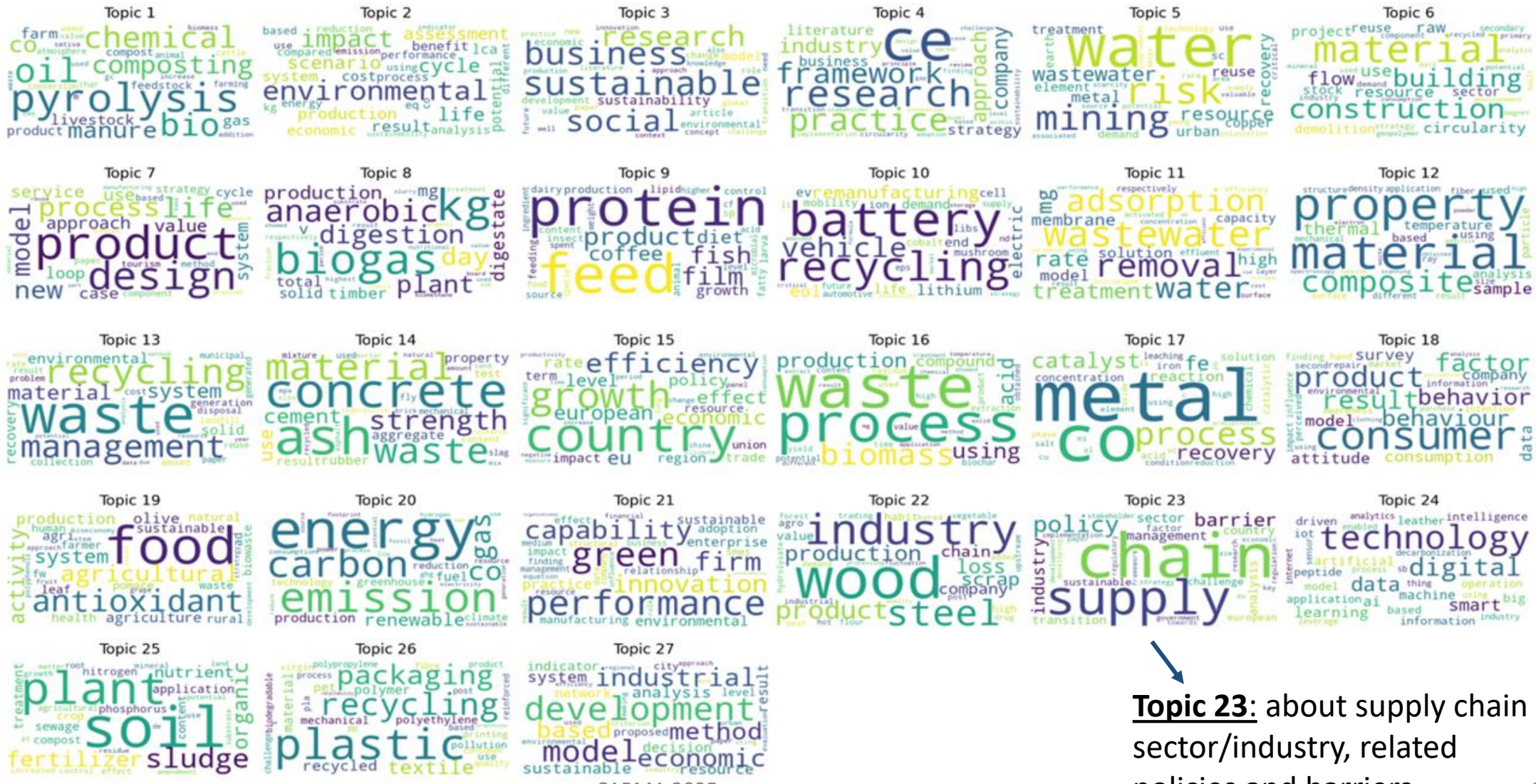
Topics - Setup

- **Algorithm**: Latent Dirichlet Allocation (LDA) on the abstracts
  - LDA: a generative statistical model that represents documents as a mixture of topics, where each topic is a distribution over words
- **Number of topics**: 27
  - This numbers gives the highest coherence value
  - Interesting finding: same as the number of subjects!
- 10 passes, 400 iterations
- Generation of **word clouds** for each topic
  - illustrating the most representative words for each topic

Topics - Results

Topic 2: about life cycle assessment (LCA) and environmental impact analysis of production systems

Topic 1: about biomass conversion processes such as pyrolysis and composting



Topic 23: about supply chain sector/industry, related policies and barriers

Conclusion

Main findings

Metadata analysis:

- CE publications have **surged in recent years** (**4323 journal articles in 2024!**), spanning **diverse disciplines**
- **Sustainability** (MDPI) and **Journal of Cleaner Production** (Elsevier) account for **16%** of all CE articles
- **Elsevier** and **MDPI** publishing **over 50%** of all CE articles
- **Italy** leads in absolute publication numbers, while **Finland** ranks highest per capita
- Top country collaborations: **China-UK**, **Italy-Spain**, **China-USA**

Content analysis:

- Core keywords: **sustainability**, **recycling**, **waste management**
  - Top linked keywords: **life cycle assessment, industrial ecology, food waste, climate change, industry 4.0, supply chain, bioeconomy,** and others
- Core RE-words (stemmed): **recycle**, **resource**, **recover,** followed by **reus**, **reclam**, **renew**, **reduct**
- Topic modeling revealed **27 main research themes** that deal with different aspects of CE

Future Work

- Explore the **evolution of country collaborations** over time

- Explore the **evolution of topics and themes** over time, to identify emerging trends and shifts in CE research

Thank you!

Questions?

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