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List of abbreviations

AIRR	Anticipation, Inclusion, Reflexibility, and Responsiveness framework
CCS	Carbon Capture and Storage
CDR	Carbon Dioxide Removal
CNKI	China National Knowledge Infrastructure database
CRMs	Critical Raw Materials
DGS	Dark Green School
EC	European Commission
EGD	European Green Deal
ESD	Education for Sustainable Development
ELI	Environmental Law Institute
EPA	Environmental Protection Agency
EU	European Union
GHG	Greenhouse Gas
GMO	Genetically Modified Organism
ICT	Information and Communication Technology
IoT	Internet of Things
KCI	Korea Citation Index database
LCA	Life-Cycle Analysis
LMTs	Land-based Mitigation Technologies
NETs	Negative Emissions Technologies
R&I	Research and Innovation
RRI	Responsible research and innovation
SDGs	Sustainable Development Goals
SRM	Solar Radiation Management
SES	Sustainable Engineering Science
SSI	Socio-Scientific Issues
UNCED	United Nations Conference on Environment and Development
VSD	Value-sensitive design

Executive summary

RE4GREEN project summary

Environmental and climate-related challenges are global and reach all sectors of society. However, research and innovation (R&I) activities that address these challenges may carry substantial unintended implications. **RE4GREEN aims to contribute to a European Research Area ethics and integrity framework for R&I activities designed to reduce the risk from such implications and to support the transition to a sustainable economy and society as envisioned by the European Green Deal (EGD).** RE4GREEN will reflect diverse stakeholder views and relate them to cross-cutting environmental and climate-related ethics issues by applying a bottom-up Social Lab methodology. RE4GREEN's framework will consist of operational research ethics and integrity guidelines, recommendations, and training materials for researchers, ethics and integrity experts and advisors, and ethics reviewers to ensure R&I activities support the Green Transition.

This deliverable reviews the academic literature on environmental justice, environmental ethics, climate justice, climate ethics, and research ethics and integrity in the context of research and innovation (R&I). It analyses the conceptualisation of these key topic areas in the literature and identifies cross-cutting concepts between these key topic areas. It represents the outcome of T1.1, and seeks to answer the following research question:

What are the cross-cutting concepts and issues in environmental ethics, climate ethics, and research ethics and integrity, and what are their implications for research, technology and innovation?

A total of 855 studies were found in relevant databases; they were each screened against inclusion and exclusion criteria by two reviewers, which led to a selection of 156 studies included in the review. The analysis found that only 43% of the reviewed studies provide an explicit definition of the key topic areas; the key conceptual components of these topic areas are synthesized in tables 3–5. Among the studies that provide an explicit definition, we also found that there is a high degree of fragmentation in understanding of environmental ethics, climate ethics, and climate justice; there is a lower degree of fragmentation in the understanding of environmental justice, but despite this there is still no shared definition of the notion of “environmental justice” in the reviewed literature.

Among the environmental topics identified, the literature also reveals an over-representation of studies focused upon climate change, at the expense of other environmental issues, such as research on biodiversity conservation. Energy technologies and geoengineering technologies also were over-represented topics in the reviewed literature, at the expense of other technology areas, such as biotechnologies and nanotechnologies; we found however some applications of the key topic areas to other technology areas, such as digital technologies and agricultural technologies.

We also found that there is very little literature that connects research ethics and integrity with environmental and climate ethics/justice: only 6% of the reviewed studies have explicit

definitions of research ethics and innovation, all of them focusing on responsible research and innovation (RRI). Importantly, this research gap was observed in both directions: not only the reviewed publications on research ethics and integrity have little to say about the environmental impact of research practices, but the reviewed publications on environmental and climate justice/ethics also have very little to say about standards of research ethics, with the notable exception of the literature on geoengineering. The research gap between environmental and climate ethics and research ethics and integrity was also observed in D1.3. This means that this research gap concerns not only the academic literature, but also existing research ethics and integrity guidelines and frameworks, as well as training programmes and materials.

We found 9 cross-cutting concepts between environmental justice and climate justice: distributive justice, procedural justice, recognition justice, intergenerational justice, energy justice, the polluter-pays principle, indigenous perspectives or traditions, and feminism (covering feminist climate justice, intersectional feminism, and eco-feminism). Broadening the scope to include research ethics and integrity, we only found three major cross-cutting concepts: responsibility, the precautionary principle, and geoengineering (covering both carbon dioxide removal and solar radiation management). We also found two minor cross-cutting concepts that are not yet playing a strong role in linking the key topic areas but that could contribute to closing the gap in future research: epistemic justice and citizenship (covering both citizen science and environmental citizenship). Comparing these results with D1.3, we found that autonomy, respect for nature, integrity, solidarity, the no harm principle, and informed consent also have the potential of playing the role of cross-cutting concepts in future research, based on the documents reviewed in research ethics guidelines and frameworks and on training resources.

The review also reflects the structural dominance of the global North in Academia, as the largest author affiliations were from the US (43% of the studies), the EU (18%) and the UK (15%). This was somewhat contrasted by the regions on which the empirical studies were conducted, with 8% of the studies conducted in Asia, 4% in Africa, 3% in Latin America, 3% in Australia, and 2% in the Middle East; however, the two most important regions in which empirical studies were conducted remain Northern America (19%) and Europe (10%). To partially mitigate this structural dominance, the review also covers literature in China, Taiwan, Korea, and Japan based on keywords in academic databases. This additional review also found that there is an important gap between the literature on environmental ethics/justice and climate ethics/justice and the one on research ethics and research integrity. It also found that research ethics and integrity was connected to environmental ethics in Korean literature through risk management, and to climate ethics through the notion of responsibility, which suggests that risk and responsibility are key cross-cutting concepts in the Korean literature.

The research conducted for this deliverable informs the work of T1.2 on the research ethics and integrity challenges of technologies and policies supporting the green transition, T1.3 on the gaps in existing training materials and programmes, and T1.4 on the research ethics and integrity frameworks and guidelines. Study tags were created to categorise the studies in the systematic literature review software Covidence to facilitate the identifications of relevant publications for T1.2 (“Specific environmental and/or climate technologies” and “Specific EU policy and/or policy document”), T1.4 and WP3 (“Research ethics and integrity guidelines”), and for each Social Lab conducted in WP2. The data extraction template was also used in T1.3 and T1.4 to identify specific

ethical and theoretical concepts, principles, domains of technology, research, and innovation, and environmental issues in training materials and programs, which will contribute to the development of guidelines in WP3 and training programmes in WP4. Finally, the cross-cutting concepts identified here, as well as the recommendations for researchers, educators, and policymakers, represent one major source of information for the development of the overall objective of integrating environmental and climate ethics considerations into research ethics and research integrity guidelines and frameworks.

Introduction

Technological innovation is a major driver of environmental degradation, as illustrated by the pollution caused by agricultural pesticides, greenhouse gas (GHG) emissions caused by the use of fossil fuels and deforestation, and the radioactive waste of nuclear power plants. At the same time, environmental and climate technologies such as renewable energy technologies, can contribute to reducing the environmental impact of economic activities. Digital technologies such as smart grids can also play an important role in the energy transition. However, both energy and digital technologies raise ethical issues, typically in terms of distributive and procedural justice, which implies that they should be designed and deployed with great care if they are to contribute to a just transition.

The relationship between research and innovation and environmental change is a complex one. This is not only due to the socio-environmental impact of research and innovation, but also to the fact that some technological innovations have the potential to advance one environmental goal at the expense of another. This is the case, for instance, when a technology promises climate benefits by cutting GHG emissions but at the same time may have harmful impacts on biodiversity, or may infringe upon human rights or exacerbate inequalities, particularly with respect to disproportionately affected groups.

This complexity, and the backdrop of the biodiversity and climate crises, make it clear that the natural environment needs to become a subject of concern in research ethics frameworks. Historically, research ethics guidelines were first developed in the field of biomedical research, with the core aim of protecting individual human participants (WMA, 1964). They have later been extended to cover the interests of participants in social sciences research and the protection of animals (WMA, 2022), sometimes even extending to the minimization of harm to the environment and the promotion of sustainability ([WMA 2024](#)). This aspect was clearly emphasised in the 2024 version. However, it is highly controversial among the addressees as to whether the WMA can have a mandate to speak for researchers outside the medical disciplines when other professional associations are not even consulted. Rather, independent research ethics approaches are necessary for the social sciences (von Unger 2014). However, research ethics frameworks still take too little account of impacts of research on the climate, biodiversity, and air, soil and water quality over short, medium, and longer timescales (Tzouvaras et al. 2025). Some initiatives propose practical approaches to integrating ethical assessments into research and innovation (R&I), such as responsible research and innovation (RRI) and value-sensitive design (VSD); such initiatives remain however largely disconnected from environmental and climate ethics concerns, as illustrated below with RRI. It is therefore challenging to integrate the findings of environmental and climate ethics into research ethics.

This literature review identifies crosscutting concepts and issues within environmental ethics, climate ethics, and research ethics and integrity, in the context of R&I. Research integrity is understood here as a subsection of research ethics, even if it is often the subject of separate guidance and courses, as we did not find enough studies on the topic that would allow us to disaggregate results on research ethics and research integrity. The review reflects the fact of pluralism among environmental values and worldviews (Pascual et al., 2023), as well as

conceptual pluralism in ethical concepts and issues within climate ethics and environmental ethics. We map similarities and gaps in this literature and in literature on research ethics and integrity, as well as concepts and issues in wider sustainability science literatures with implications for R&I.

This literature review seeks to answer the following research question:

What are the cross-cutting concepts and issues in environmental ethics, climate ethics, and research ethics and integrity, and what are their implications for research, technology and innovation?

Specific objectives are to:

- Map the conceptual overlaps between environmental ethics, climate ethics, and research ethics and integrity.
- Map synergies and tensions between concepts in environmental ethics and climate ethics, including indigenous and local knowledge.
- Map overlaps and gaps between implementation or operationalization of concepts within guidelines, norms and principles.
- Map the application of these concepts for the topics of technology, and innovation.
- Identify ethical issues raised by research, technology and innovation in relation to climate change and other environmental issues.
- Identify key principles or guidelines which should be followed to mitigate these ethical issues in relation to research, technology, and innovation.

The first section (Systematic review method) explains the search methodology for identifying and analysing the relevant literature. The second section (Findings) presents the main findings of the literature review, in relation to the main objective and the specific objectives presented above. After discussing some general findings, this section moves to the conceptualisation of the key topic areas of environmental justice, climate justice, environmental ethics, and research ethics and integrity – these notions were not pre-defined, as one objective of the review is to see how they are conceptualised in the literature. This section also investigates the relation between these key topic areas. The third section (Discussion) builds on these findings to identify cross-cutting concepts between the key topic areas that have been previously defined. It also reviews the guidelines, frameworks, and principles discussed in the literature, as well as the recommendations for researchers, educators, and policymakers. It finally includes a discussion and comparison with the literature on the key topic areas in China, Taiwan, Korea, and Japan. The conclusion provides some critical considerations on the key findings and suggests areas for future research.

1. Systematic Review Method

A scoping review method was chosen, as this type of literature review is well-adapted for mapping concepts, investigating how they relate, and identifying gaps between different research fields (Peters et al., 2015; Sutton et al., 2019). This scoping review has been conducted following best practices for scoping reviews, based upon Arksey and O'Malley (2005). It was also performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and PRISMA Extension for Scoping Reviews (PRISMA-ScR).

Article Selection

The search strategy was designed in partnership with consortium members and the Embedded Information Services (EIS) of the Library, ICT Services and Archive (LISA), a service within the University of Twente, with the support of Information Specialists Marit van Eck and Kasandra Poague from the Behavioral, Management and Social Sciences (BMS) Faculty.

We used three databases to cover a wide range of the academic literature on the key topic areas: Scopus, Web of Science, and Philosopher's Index. One limitation of this review is that it excludes grey literature on the key topic areas, e.g., from international organisations' reports, policy briefs, and governmental position papers. We decided to only include academic literature to concentrate on peer-review scientific publications and review and synthesise the key ideas being discussed in the current body of academic knowledge. Another limitation of these databases is that they reflect the historical dominance of research institutions in Northern America and Europe and the research standards in place in these regions.

The review aims to map the relation between environmental ethics, climate ethics, and research ethics and integrity in the context of R&I. We looked for concepts, topics, and issues that are related to or that represent aspects of: environmental ethics, environmental justice, climate ethics, climate justice, research ethics and integrity, and environmental risks. These concepts, topics, and issues are only considered in relation to innovation and technology.

We included all literatures that mention the concepts or issues outlined. There is no restriction on the geographical location of studies, or the research disciplines in which these concepts can be used. The review considered all peer-reviewed publications, without a time limitation. This includes peer-reviewed research articles, books, book chapters, and review articles.

We included literature written in English, French, German, and Spanish, although the search has been performed solely in English at this stage. This means that French, German and Spanish literature with titles and abstracts available in English identified using English language search terms have been included and analysed. English, French and German are among the official and working languages of the EU institutions; these are the three "procedural languages" in which the European Commission conducts its internal business. In addition to this, much of the research in EU research institutions is conducted and published in one of these three languages.

Spanish was selected as another EU language and as one of the most widely spoken language in the world.

Publications in French, German, and Spanish were found in the initial search and included in the reviewing process, but because of the low number of publications identified in these languages and the lack of equivalence between these publications and our inclusion and exclusion criteria, in the end only publications in English were included. We translated the search strings into French, German, and Spanish to use them in databases in these languages, but these databases did not have complex search functionalities and did not produce any useful results.

Because of the plurality and complexity of topics covered by the review, multiple versions of the search strings have been discussed to find the formulation that is the most adapted to the objectives of the study. One challenge when designing the search string was to ensure that the results included the key topic areas of environmental ethics/justice, climate ethics/justice, and research ethics and integrity; another challenge was to track exclusively publications discussing environmental and/or climate concerns. It was decided to restrict the search to publications whose keywords mention the climate or the environment as well as technology or innovation, without mentioning “research” in this part of the search string, as this systematically led to thousands of hits, most of which were not relevant for the review; the inclusion of research ethics and research integrity at the beginning of the search string however guaranteed that the literature contributing to these key topic areas was taken into account. A separate intercultural search string has been designed to integrate a plurality of normative perspectives in the literature on the relation between these topics, including indigenous and local knowledge (see Table 1). The intercultural search string is based on an IPBES systematic literature review (Athayde et al. 2022) with the addition of keywords relevant for this scoping review. The searches were done in the three databases on 7th May 2024. The final search queries are displayed in Table 1.

Table 1: Search strings

Database	Search string
Scopus	TITLE-ABS-KEY ((research W/3 ethic*) OR (research W/3 integrity) OR (climate W/3 ethic*) OR (environ* W/3 ethic*) OR (climate W/3 justice) OR (environ* W/3 justice)) AND KEY ((climate OR environ*) AND (technology OR innovation))
Web of Science	TS=((research NEAR/3 ethic*) OR (research NEAR/3 integrity) OR (climate NEAR/3 ethic*) OR (environ* NEAR/3 ethic*) OR (climate NEAR/3 justice) OR (environ* NEAR/3 justice)) AND AK=((climate OR environ*) AND (technology OR innovation))
Philosopher’s Index	SU ((research N3 ethic*) OR (research N3 integrity) OR (climate N3 ethic*) OR (environ* N3 ethic*) OR (climate N3 justice) OR (environ* N3 justice)) AND SU ((climate OR environ*) AND (technology OR innovation))
Scopus (Intercultural search string)	TITLE-ABS-KEY (indigenous OR local) AND (pastoralis* OR herder OR fisher* OR hunt* OR forest* OR agriculture OR livelihood OR nomad OR land* OR river* OR sea OR ocean OR mountains) AND (knowledge OR philosophy) AND (values) AND (

nature OR mother AND earth OR biodiversity OR ecosystem) AND KEY ((climate OR environ*) AND (technology OR innovation))

Analytical Procedure

We used the online software Covidence for managing imported references, removing duplicates, and managing the screening process. The review process took place in three stages: first, publications were screened based on title and abstract against inclusion and exclusion criteria; second, the remaining subset of publications were screened based on the full text against elaborated inclusion and exclusion criteria (see table 2); third, the data relevant for the review has been extracted based on a data extraction template.

Table 2: Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
<p>1. Language: English, French, German, Spanish</p> <p>2. Topic: Substantial usage or analysis of any of the following concepts or topic areas:</p> <ul style="list-style-type: none"> • Aspects of environmental ethics/justice • Aspects of climate ethics/justice • Aspects of sustainability ethics • Environmental risk • Research ethics/integrity (connected to environmental impact) <p>By 'substantial usage or analysis', we require articles to provide one or more of the following:</p> <ul style="list-style-type: none"> • Explicit definitions of these concepts or topics, supported by reference to literature • Usage of these concepts within analysis of the research conducted, either as part of methods/approaches or as part of findings/conclusions <p>3. Types of records: published scientific articles, review articles, book chapters, books</p>	<p>1. Language: all other languages (incl. when abstract is in English but paper is in another language, since we cannot read the full text)</p> <p>2. Wrong topic:</p> <ul style="list-style-type: none"> • Where concepts or topics are peripheral to the analysis conducted, e.g. are included as potential further implications of the study that were not analysed within it; • Where concepts or topics are not defined or referenced – corresponding to the conditions for exclusion for 'generic usage'. <p>These conditions are the following:</p> <ul style="list-style-type: none"> • Generic/vague usage of 'ethics in research' or 'ethical issues in research' or 'research integrity' without application to environmental sustainability or environmental impacts or synonyms • Generic/vague usage of 'ethics' or 'justice' or 'equity' or 'intergenerational justice' or 'social justice' or 'gender justice' or 'business ethics' unconnected to environmental/climate impacts or environmental sustainability or synonyms • Irrelevant/metaphorical usage of search terms with different meanings, e.g. 'work environment', 'business climate'

- Use of 'sustainability' (e.g. corporate sustainability) with no mention of environmental sustainability or synonyms

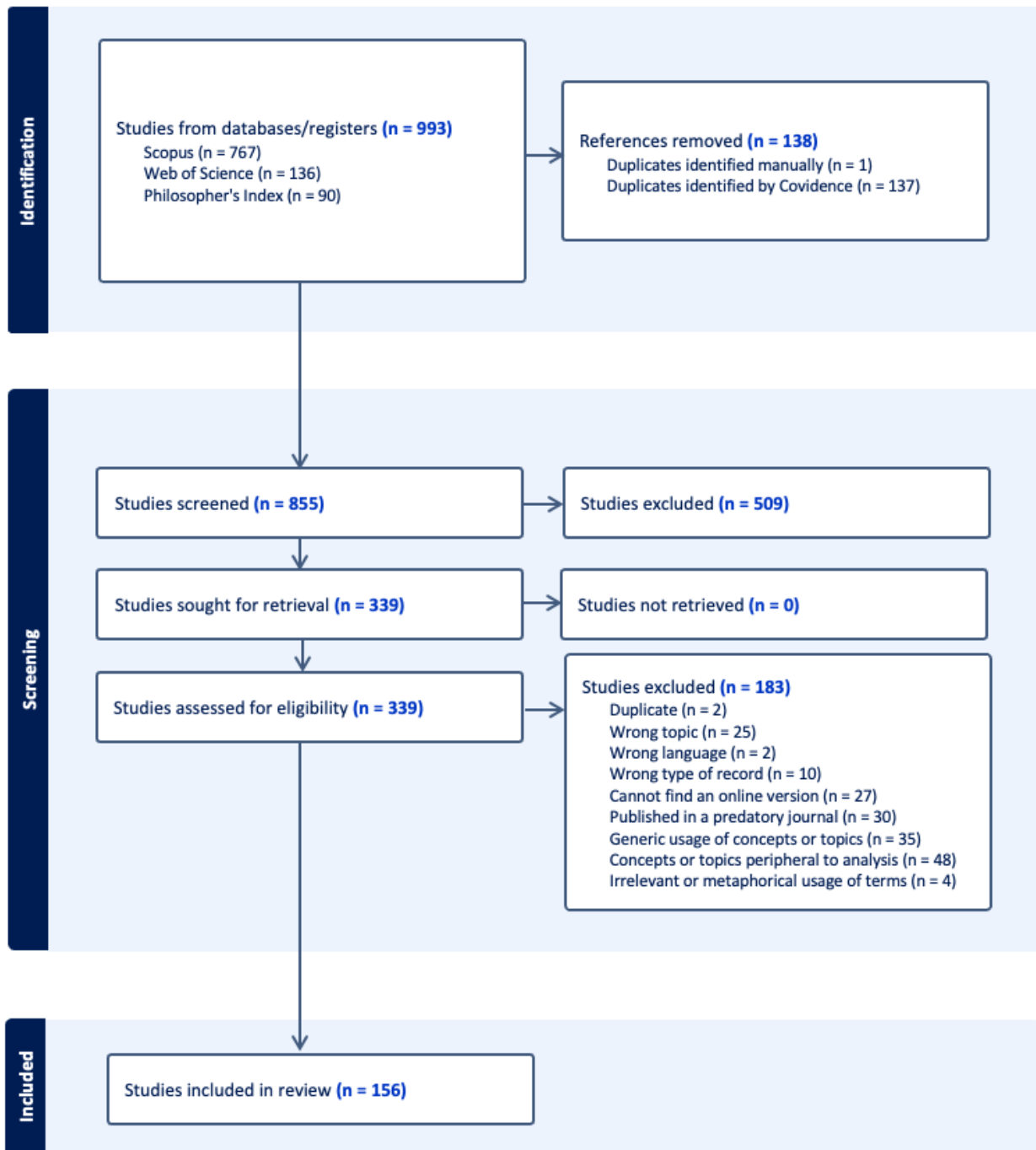
3. Types of records:

- Unpublished texts, e.g. grey literature, preprints
- Non-peer reviewed, e.g. letters, comments, editorials, book reviews, policy briefs, policy statements
- Duplicates
- Published in a predatory journal (peer review not verifiable), e.g. does not appear in the Directory of OA Journal (<https://doaj.org/>) or appears on the Predatory Journal's list (<https://predatoryjournals.org/predatory-journals>).

Note: When there are two versions of a paper, a proceeding/working paper version and a peer-reviewed journal-based publication, the latter is included.

All members of the review team took part in the three steps of the review process. The deduplicated search results were distributed among the team, using the program Covidence. At stage 1 (title and abstract screening), a sample of publications was initially distributed for a pilot study to validate the inclusion and exclusion criteria. The initial inclusion and exclusion criteria were modified inductively in light of the pilot study and were agreed upon before the start of stage 1. The same process took place at stage 2 (full text screening). To reduce bias, two reviewers were allocated to each publication for each step; any disagreement regarding the inclusion or exclusion of a publication was discussed in team meetings to reach consensus. The number of publications included and excluded at each stage is displayed in figure 1.

Figure 1: Flow Chart of Selection Process



A total of 855 publications were found by the search in the three databases and were screened in the first step of the review (title and abstract screening); in the second step (full text screening), 339 studies were screened, and a total of 156 studies were selected for the third and final step (data extraction). The main reasons for rejecting the publication at the second stage were the fact that the key topic areas played only a peripheral role in the analysis (48 studies), that the key topic areas were only used in a generic way (35 studies), that the study was published in a predatory journal (30 studies), that the online version of the text could not be found (27 studies), and that the study was on the wrong topic (25 studies). To identify predatory

journals, we used the Predatory Journals list (<https://predatoryjournals.org/predatory-journals>) as well as the Directory of OA Journals (<https://doaj.org/>). When we could not find a study online, we contacted the (lead) author to ask for a copy of the publication, and we rejected the study only in cases where the author did not reply.

We were as inclusive as possible and used a wide interpretation of the “substantial usage or analysis of the key topic areas” inclusion criterion: as long as the publication provided an explicit definition of the key topic area(s) discussed, or as long as it used the key topic area(s) as part of the methods methods/approaches or as part of findings/conclusions, it was included at the third stage.

Various attributes of each publication included for the review were recorded in data extraction files. The data was extracted from Covidence in RIS format and saved into a reference management software (Zotero) and converted into an Excel document.

The data extraction file contains the following information:

1. Study ID (lead author and year of publication)
2. Title of publication
3. Doi
4. Full list of authors
5. Year of publication
6. Journal, chapter, or book title
7. Lead author affiliation
8. Region in which the study was conducted (if any)
9. Study type (research field)
10. Theoretical approach
11. Key topic area(s) covered in the publication
12. Definition of topic area(s) (if provided)
13. Connection between topic areas (if provided)
14. Key references cited in definition (if any)
15. Specific ethical or theoretical concepts applied to key topic area (if any)
16. Principles or guidelines/frameworks (if any)
17. Domains of technology/research/innovation (if provided)
18. Environmental issue(s) discussed in the paper (if provided)
19. Research ethics and integrity guidelines/frameworks (if provided)
20. Recommendations for policymakers (if provided)
21. Recommendations for researchers (if provided)
22. Recommendations for educators (if provided)
23. Key quotation (optional)
24. Notes (optional)

Study tags were created in Covidence so that reviewers could categorise publications in the first two steps of the review. This was meant to facilitate the identifications of relevant publications for T1.2 (“Specific environmental and/or climate technologies” and “Specific EU policy and/or policy document”), T1.4 and WP3 (“Research ethics and integrity guidelines”), and for each Social Lab conducted in WP2 (“SL1+7: Health, Culture and inclusive society, Civil security”; “SL2: Digital, Industry and Space”; “SL3: Climate and Mobility”; “SL4: Energy” “SL5: Fresh Waters and Oceans”; “SL6+8: Food, Bioeconomy, Agriculture, and Environment; Soil; Natural Resources”). The data extraction template created for the third step of the review was used in T1.3 to identify specific

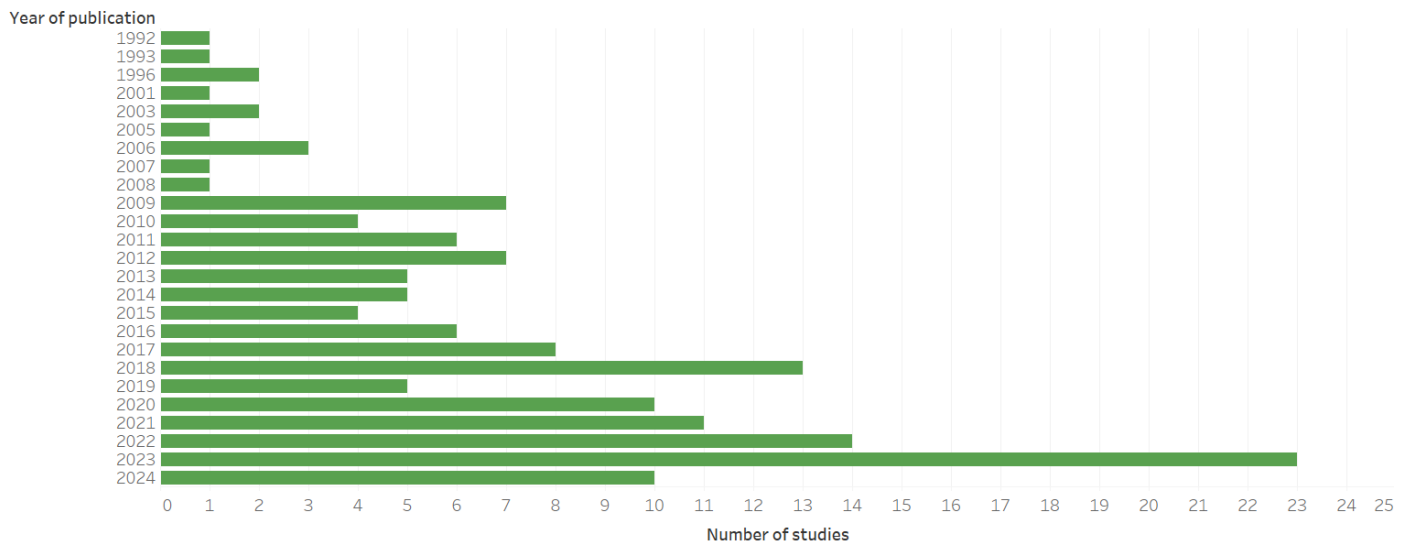
ethical and theoretical concepts, principles, domains of technology, research, and innovation, and environmental issues in training materials and programs, which will contribute to the development of training programmes in WP4. The findings of T1.3 and T1.4 can be found in D1.3, which was completed in January 2025 (Tzouvaras et al. 2025).

2. Findings

General findings

We start this findings section by providing some background information on the reviewed literature. The first relevant finding concerns the evolution of the publications on the key topic areas over the years (figure 2).

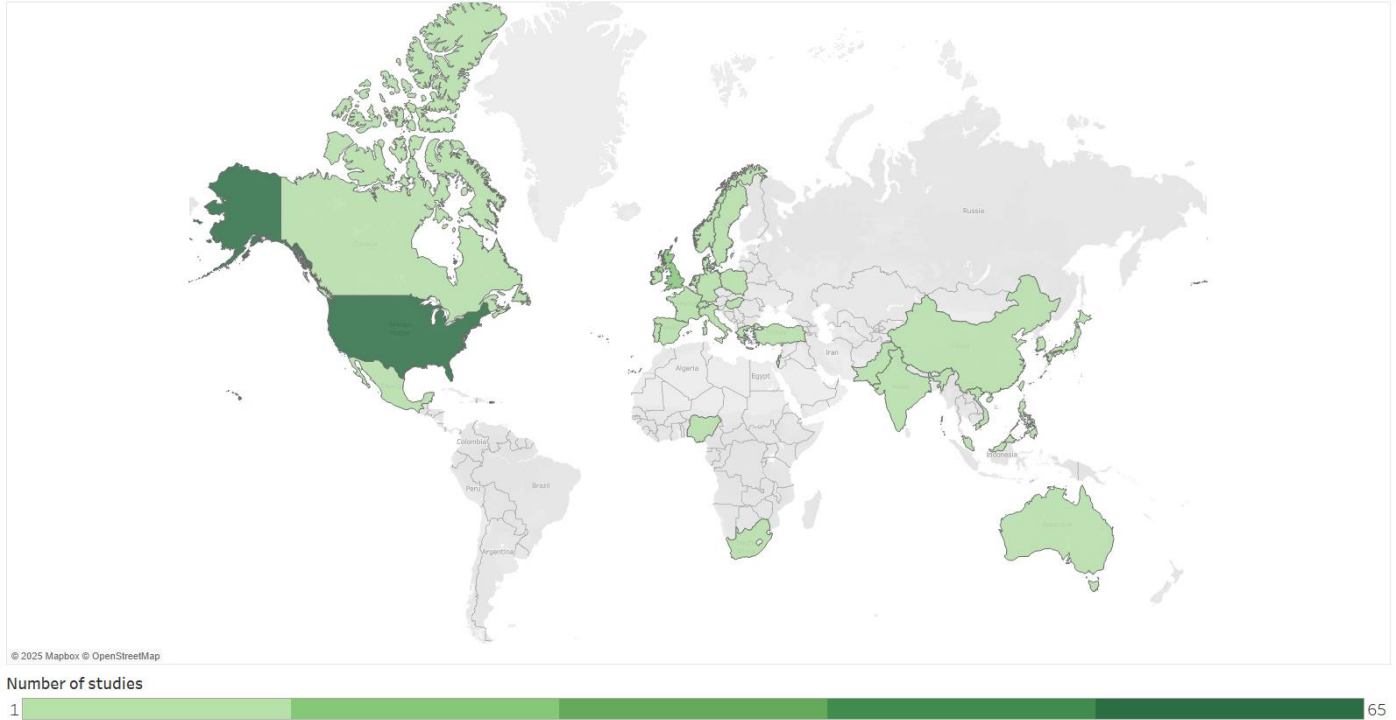
Figure 2: Number of publications across the years



From 1992 to 2008, very few relevant papers were identified. From 2009 onwards, we observe a gradual increase in publications on the key topic areas. The years with the highest number of publications are 2023 (23 publications, 15%), 2022 (14 publications, 9%), and 2018 (13 publications, 8%). Data for 2024 is incomplete since the search was conducted in May 2024.

The second general finding concerns the geographical repartition of lead author affiliation (figure 3)

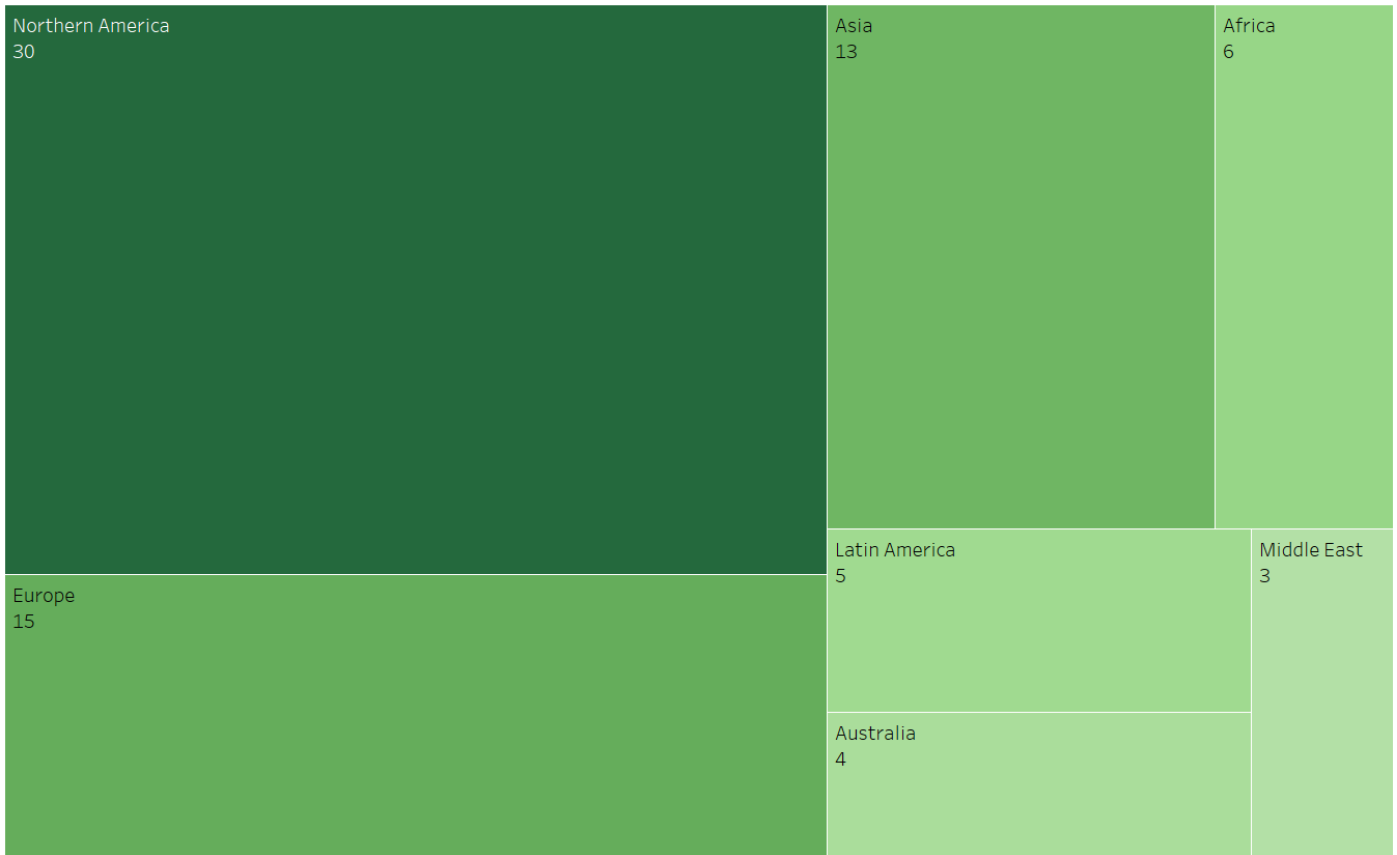
Figure 3: Lead author affiliation



Most of the studies were conducted by researchers based in Northern America, Western and Southern Europe, and Australia, as indicated by lead author affiliation. The largest author affiliations were from the US (67 studies, 43%), the EU (28 studies, 18%) and the UK (23 studies, 15%). This probably had an influence on the kind of (ethical) approaches adopted by the authors of these papers when discussing the key topic areas. Several studies were, however, published by authors affiliated in Asia (China, India, Japan, Malaysia, Philippines, Pakistan, South Korea, Taiwan, and Vietnam), Central and Eastern Europe (Greece, Hungary, and Poland), Africa (Nigeria and South Africa), the Middle East (Israel and Türkiye), and Latin America (Mexico). This contributed to broadening the perspectives that were part of the literature review, but there remains a strong dominance of researchers working in Northern American and European research institutions. This may be due to the databases from which publications were extracted, as explained in the methodological section above.

This dominance is confirmed by the regions on which the empirical studies that were part of the reviewed literature were conducted (figure 4).

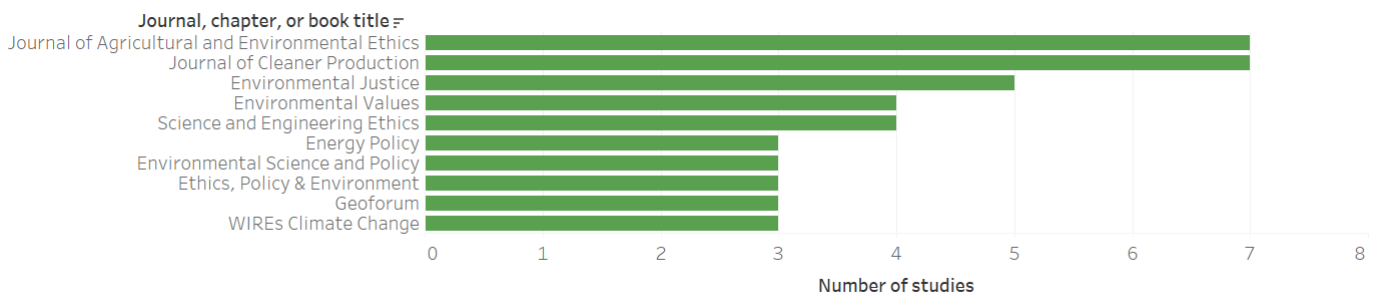
Figure 4: Regions in which empirical studies were conducted



As this figure shows, 30 studies (19%) were conducted in a Northern American context and 15 (10%) in a European context. However, some case studies were conducted in other regions, with 13 in Asia (8%), 6 in Africa (4%), 5 in Latin America (3%), 4 in Australia (3%), and 3 in the Middle East (2%). This also contributed to broadening the geographical scope of the review, keeping in mind that this scope could be further extended.

The dominance of Europe and Northern America can also be illustrated by the most frequent journals in which the reviewed studies were published (figure 5)

Figure 5: Most frequent sources



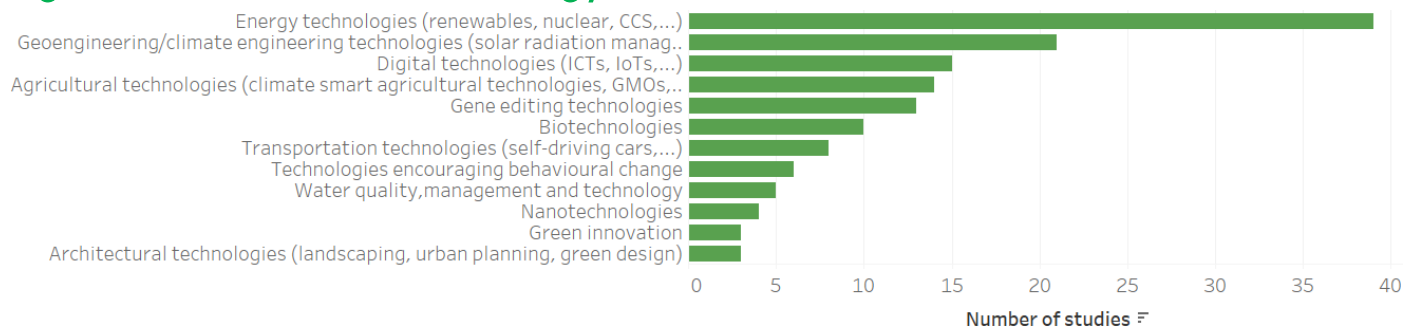
The most frequent journals are situated in Europe or in the US: The *Journal of Cleaner Production* (7 studies, 4%), *Energy Policy* (3 studies, 2%), *Environmental Science and Policy* (3 studies, 2%), and *Geoforum* (3 studies, 2%) are published by the Dutch publishing company Elsevier; the *Journal of Agricultural and Environmental Ethics* (7 studies, 4%) and *Science and Engineering Ethics* (4 studies, 3%) by the German and British publishing company Springer

Nature; *Environmental Justice* (5 studies, 3%) by the US publishing company Mary Ann Liebert; *Environmental Values* (4 studies, 3%) by the US publishing company SAGE; *Ethics, Policy and Environment* (3 studies, 2%) by the UK publishing company Taylor & Francis; and *WIREs Climate Change* (3 studies, 2%) by the US publishing company Wiley.

As expected, the most frequent sources are ethics and/or political theory academic journals: *Environmental Justice*, *Environmental Values*, *Ethics, Policy and Environment*, *Journal of Agricultural and Environmental Ethics*, and *Science and Engineering Ethics*. *WIREs Climate Change* publishes review articles; the remaining journals publish articles in environmental science and policy.

Turning to the content of the publications, the domains of technology or innovation discussed in the literature are displayed in figure 6.

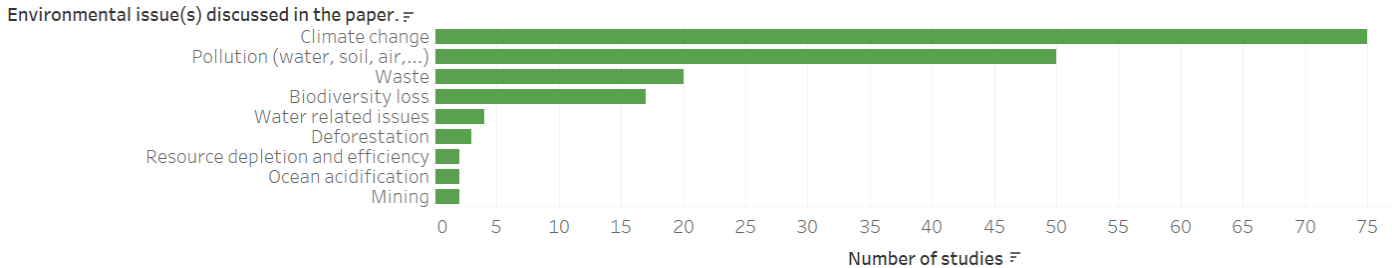
Figure 6: Domains of technology and innovation



The domains of technology and innovation that are discussed in 10 publication or more are: energy technologies (including carbon capture and storage (CCS)); geoengineering or climate engineering technologies (including both solar radiation management (SRM) and carbon dioxide removal (CDR)); digital technologies, such as information and communication technologies (ICTs) and the Internet of things (IoT); agricultural technologies, such as climate smart agricultural technologies and genetically modified organisms (GMOs); gene editing technologies; and biotechnologies. Other important but less frequently mentioned domains include transportation technologies, technologies encouraging behavioural change, water quality and management technologies, nanotechnologies, green innovation, and architectural technologies (including landscaping, urban planning, and green design). Energy technologies and geoengineering technologies are clearly the most important domains of technology and innovation discussed in the reviewed literature.

The last general finding concerns the environmental issues discussed in the literature (figure 7).

Figure 7: Environmental issues discussed in studies



The four environmental issues that are the most frequently mentioned are climate change, pollution (including water, soil, air, and other types of pollution), waste, and biodiversity loss, with a clear over-representation of climate change and pollution. Water related issues, deforestation, resource depletion and efficiency, ocean acidification, and mining are also mentioned but less frequently discussed. It was expected for climate change to come at the top of the list, as it is at the centre of climate ethics or justice and is often discussed, although to a lesser extent, in environmental ethics or justice. Environmental justice tends to be more focused on pollution, waste, and environmental ethics on biodiversity loss, which may explain why these issues are ranked second, third, and fourth, respectively. There is also a direct connection between figures 6 and 7, as energy and climate engineering technologies are discussed in the context of climate change, and agricultural technologies, biotechnologies, and gene editing technologies are linked to pollution, waste, and biodiversity loss. There are also overlaps between these categories, as the disposal of nuclear waste and other energy technology waste is also a problem of pollution and waste management, and some geoengineering projects might have major impacts on biodiversity. The relations between these categories are therefore complex, but these two tables are only meant to illustrate the types of technological innovations and environmental issues covered in the literature.

Conceptualisations of key topic areas

Explicit definitions of the key topic areas were found in a total of 67 articles (43%). As such, a clear majority of 89 articles lacked clear definitions of these topic areas (57%), despite the fact that they played a central role in the study. Among articles featuring definitions of key topics, the review found limited evidence of shared understandings in the literature surveyed, with considerable variation in basic definitions or applications to areas of R&I.

51 studies mentioned **environmental justice** (33%), with 45 explicit definitions (29%). Despite this, relatively few shared definitions or understandings across the literature were found. The most mentioned definition of environmental justice was provided by Schlosberg (2002, 2004, 2007, 2013), which was cited in 15 studies (10%). This also covers distributive and procedural or participative justice but adds recognition of the diversity of concerns and pluralistic values in environmental justice, and an interest in capabilities conceived as the basic needs and functionings of individual and collective agents. A smaller group of 5 studies (3%) refer to the definition of environmental provided by the US Environmental Protection Agency (EPA, 1998), which emphasises distributive justice – in terms of allocation of negative environmental

consequences – and participatory justice – in terms of the inclusion of all people in the political process leading to environmental decision making. Aside from these two sources, few common definitions of environmental justice appeared to be available. One additional conceptual component was restorative justice. Table 3 provides an overview of the conceptualisations of environmental justice from the reviewed literature, together with the number of mentions with an explicit definition and the references providing the definition.

Table 3: Key conceptual components of environmental justice from the included literature

Conceptual element	Definition	Mentions	References
Distributive justice	Involves the fair distribution of environmental benefits and burdens across individual and collective agents. It ensures both that individuals and groups have access to a fair share of environmental benefits and that no individual or group is exposed to an inequitable allocation of negative environmental impacts.	7	(Batel & Devine-Wright, 2017; Behrsin, 2020; Bettini et al., 2020; Bush & Doyon, 2023; Kurochkin et al., 2021; McCauley & Heffron, 2018; Ziegler et al., 2023)
Procedural justice	Emphasizes the importance of inclusive, transparent, and democratic decision-making processes. It ensures that all the stakeholders affected by environmental policies have meaningful participation opportunities in the political process guiding the design and implementation of these policies. Particular attention is paid to those who have historically been marginalized or excluded from the decision-making process.	7	(Batel & Devine-Wright, 2017; Behrsin, 2020; Bettini et al., 2020; Bush & Doyon, 2023; Kurochkin et al., 2021; McCauley & Heffron, 2018; Ziegler et al., 2023)
Recognition justice	Focuses on acknowledging and valuing the diverse perspectives and experiences of different social, cultural, ethnic, racial, and gender groups, and addressing any forms of misrecognition or non-recognition. It is related to procedural justice, with the idea that all groups with a stake in environmental decision-making processes should have their interests and positions recognized and represented.	5	(Batel & Devine-Wright, 2017; Behrsin, 2020; Bettini et al., 2020; Bush & Doyon, 2023; Ziegler et al., 2023)
Restorative justice	Involves addressing past environmental harms through compensation, restitution, and resolution for people and communities	5	(Kaul et al., 2023; Kurochkin et al., 2021; McCauley & Heffron, 2018; Tomblin, 2009; Vaishnav, 2023)

	affected by such harms, as well as the remediation of damages.		
Justice as capability	Ensures that individuals and communities do not only have the necessary resources, but also the necessary opportunities to convert these resources to live healthy, safe, flourishing, and dignified lives. Promoting capabilities fulfillment includes providing access to environmental benefits but also protecting from environmental harms.	2	(Behrsin, 2020; Bush & Doyon, 2023)

Next, 42 studies mentioned **environmental ethics** (27%), with 34 providing explicit definitions of this as a field of study, or explicit definitions of specific concepts within environmental ethics (22%). As this field is often characterised in terms of the *scope of ethics*, or the question of ethical considerability, the topic of nonanthropocentrism, i.e. the rejection of human-centredness (17 mentions, 11%), was prominent in the literature surveyed. Other topics included sentientism, i.e. recognition of the intrinsic value of sentient non-human animals capable of experiencing pleasure and pain; biocentrism, i.e. recognition of the intrinsic value of living beings, ecocentrism, i.e. recognition of the intrinsic value of ecological systems or collectives, ecofeminism, deep ecology, and environmental virtue ethics. A somewhat disconnected literature on the concept of corporate environmental ethics was also identified, with 8 studies utilising this approach to develop their argument (5%). This was defined most often by reference to a review article on environmental ethics written by Palmer, McShane, and Sandler (2014), which does not mention the topic of corporate environmental ethics. This suggests that the concept lacks a clearly discernible meaning. Table 4 provides an overview of the conceptualisations of environmental ethics from the reviewed literature, together with the number of mentions with an explicit definition and the references providing the definition

Table 4: Key conceptual components of environmental ethics from the included literature

Conceptual element	Definition	Mentions	References
Ecocentrism	Collective beings, such as ecosystems and species, have intrinsic value.	10	(Baum & Owe, 2023; Bhardwaj, 2006; Biasseti & Grigoletto, 2023; Green, 2024; King, 2006; Okada & Watanabe, 2008; Petit & Guillaume, 2018; Shrader-Frechette, 2005; van Wynsberghe & Donhauser, 2018; Verharen et al., 2021)
Biocentrism	All living beings, including plants, have intrinsic value.	8	Baum 2023, King 2006, Okada 2008, Shrader-Frechette 2005, Green

			2024, Biaasetti 2023, Bhardwaj 2006, van Wynsberghe 2018
Anthropocentrism	Non-human natural beings only have instrumental value, in the sense that their value derives from their usefulness to humans; only human beings have intrinsic value and should be considered as ends in themselves.	6	(Bhardwaj, 2006; Cera, 2020; Green, 2024; Petit & Guillaume, 2018; Shrader-Frechette, 2005; van Wynsberghe & Donhauser, 2018)
Ecofeminism	Focuses on the gendered nature of environmental inequalities and on the relation between people and places, recognizing how power can culture are infused within networks that are rooted in place.	6	(Lloro-Bidart & Finewood, 2018; Mahoney, 2016; Roe & Zavar, 2021; Shrader-Frechette, 2005; Stephens, 2024; Wiseman, 2022)
Sentientism	All sentient non-human animals have intrinsic value; sentient beings capable of experiencing pleasure (interest satisfaction) and pain (setback in interest) have moral standing.	4	(Baum & Owe, 2023; King, 2006; Okada & Watanabe, 2008; Shrader-Frechette, 2005)
Environmental virtue ethics	Focuses on characters and dispositions we ought to adopt regarding the environment, complementing the ethic of action with an ethic of character, and asking questions related to the good life rather than the right action.	4	(Anthony, 2012; Coeckelbergh, 2011; Dzwonkowska, 2017; Mahoney, 2016)
Deep ecology	The natural environment as a whole, not only species or ecosystems, has intrinsic value. Deep ecology themes include showing respect for nature, being one with nature, and engaging in environmental activism.	2	(Okada & Watanabe, 2008; Shrader-Frechette, 2005)

Turning to **climate justice**, and the closely related concept of **climate ethics**, we found even less evidence of shared understandings across the literature reviewed. A total of 33 studies reviewed discussed climate justice or climate ethics (21%), with 20 providing definitions of these terms (13%). Contrary to our initial hypothesis, the work of Shue (1993, 2005, 2014) and Caney (2009, 2010, 2014), which is particularly influential in philosophical literature on responsibilities for mitigating and adapting to climate change were only cited in 4 articles in this wider literature. Three articles cited the work of Adger and colleagues (Adger et al., 2006; Paavola & Adger, 2002) on adaptation to climate change. Other literature emphasised transformative change as central to climate justice, gender justice, or power relations. Instead, most studies offered their own definitions of climate justice, supported by different references in many cases. More specific concepts within climate justice research were also found, such as the polluter pays principle (10 mentions, 6%) and the ability to pay principle (3 mentions, 2%). Table 5 provides an

overview of the conceptualisations of climate justice from the reviewed literature, together with the number of mentions with an explicit definition and the references providing the definition.

Table 5: Key conceptual components of climate justice from the included literature

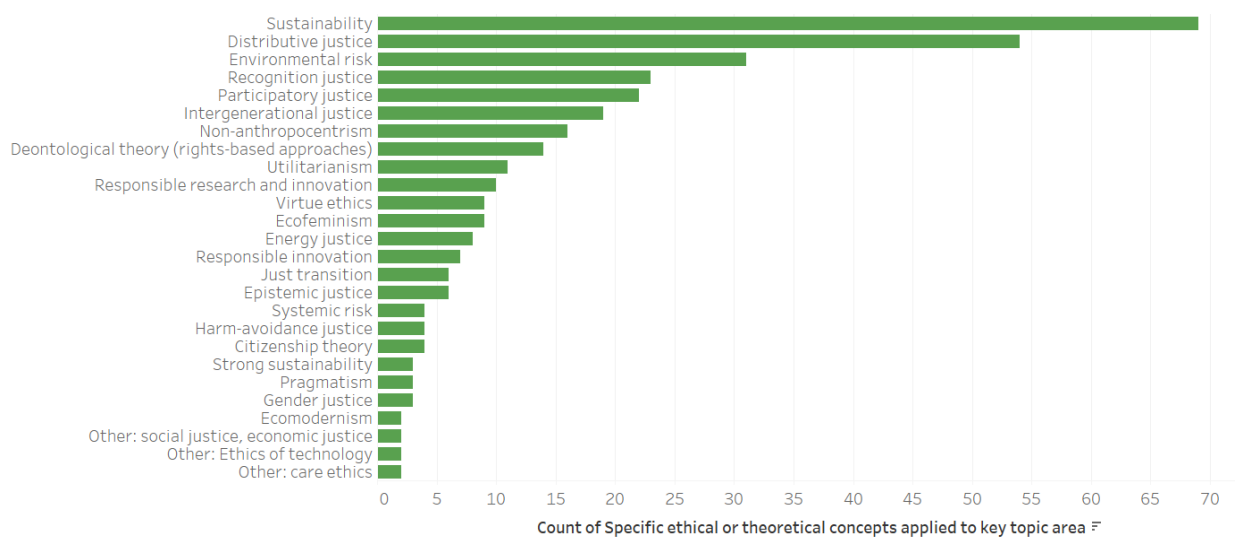
Conceptual element	Definition	Mentions	Reference
Burden-sharing justice	Refers to the allocation of responsibility for addressing climate change between countries and across generations, with the objective to obtain a fair distribution of the costs of climate policies such as mitigation, adaptation, and loss and damage policies.	9	(Bourban, 2022; Bush & Doyon, 2023; Hilser et al., 2024; Khayat, 2023; McAllister et al., 2014; McCauley & Heffron, 2018; Okereke, 2010; Popke et al., 2016; Ying & Sovacool, 2021)
Procedural justice	Refers to the fair participation to decision-making processes that shape climate policies.	5	(Forsyth & McDermott, 2022; Hilser et al., 2024; McCauley & Heffron, 2018; Okereke, 2010; Popke et al., 2016)
Restorative justice	Aims at redressing the past harms of extractive activities, coloniality, economic injustice, and systems of exploitation that maintain and increase the vulnerability to climate impact of people and communities suffering from historic injustices.	3	(Kinol et al., 2023; Okereke, 2010; Stephens & Sokol, 2023)
Recognition justice	Refers to the acknowledgement of people's diverse needs and experiences in the design and implementation of climate policies.	2	(Hilser et al., 2024; Popke et al., 2016)
Harm avoidance justice	Aims at ensuring that the most vulnerable to climate impacts are protected and that climate policies do not result in further harming the global poor.	1	(Bourban, 2022)

Turning to **research ethics and integrity**, the focus is on normative issues raised by participation in the development of knowledge and the use of knowledge. Since this review included publications on research ethics and integrity only insofar as these included an explicit and clear consideration of environmental impact, we anticipated that much of the existing literature on these topics would be excluded. Nonetheless, we were surprised by how little of this literature was identified. Of the literature included, 10 articles had explicit definitions pertaining to research ethics and integrity (6%), but only in terms of the concept of **Responsible Research and Innovation (RRI)**, which articulates the topic of knowledge production with that of knowledge application. RRI's major aim is to align the governance of novel fields of science and

technology with societal values by creating, maintaining, and developing the dialogue between scientific production, technology innovation, and society, for instance through deliberative conversations between academic and non-academic stakeholders. The idea that research and innovation should also contribute to sustainability is also part of this framework. The following definition by the European Commission is cited in Biddle (2017): “Responsible research and innovation is an approach that anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation.” More considerations on the inclusion of environmental and climate concerns in research ethics and innovation guidelines and frameworks from the reviewed literature are discussed in the next section (see “Guidelines, frameworks, and principles” and “Recommendations for researchers”).

This research gap in the academic literature between environmental and climate ethics and research ethics and integrity was also observed in D1.3 (Tzouvaras et al. 2025). Out of 213 research ethics and integrity guidelines and frameworks that were reviewed in T1.4, 123 (58%) made no reference to climate or environmental concerns; engagement with climate or environmental ethics was often superficial and lacked depth or actionable guidance in the remaining 90 resources. Likewise, out of the 370 training programmes and materials that were reviewed in T1.4, 305 (82.4%) addressed climate and environmental aspects of research and innovation, but only 43 (11.6%) showed some engagement with research ethics and integrity specifically. The research gap concerns therefore not only the academic literature, but also existing research ethics and integrity guidelines and frameworks, as well as training programmes and materials. To conclude this sub-section, it is helpful to look at the ethical or theoretical concepts most commonly used to discuss the key topic areas (see figure 8).

Figure 8: Specific ethical or theoretical concepts applied to key topic areas



Our review method did not require these concepts to be clearly defined in the studies reviewed, nor even to play an important role in the analysis to appear in our results here; it was sufficient for them to be mentioned to appear in table 8. An analysis that looks more closely at how some

of these notions are defined and what role they play in linking the key topic areas is provided in the next section. Here, we are just looking at the number of occurrences of ethical and theoretical concepts.

The concept that is the most often mentioned – in 73 studies (47%) – is sustainability. Given the topicality of this concept, this does not come as a surprise, but it is still relevant to note that it appears in so many studies, as this indicates that there is a strong connection between sustainability and ethics and justice-related issues related to environmental problems. Sustainability was also the most important ethical concept in the training resources reviewed in D1.3, with 56.3 % of the training material descriptions and 64.9% of the training programme descriptions mentioning it. It played also an important albeit smaller role in the research ethics and research integrity frameworks and guidelines, where it was mentioned in 16.9% of the reviewed documents (Tzouvaras et al. 2025).

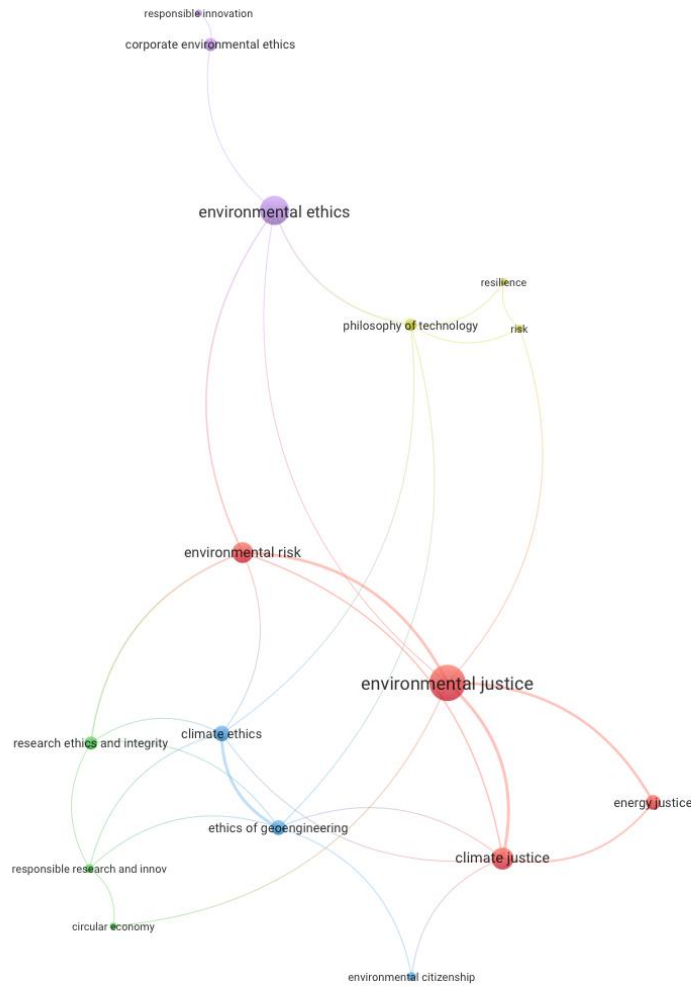
Distributive justice (ranked 2nd), recognition justice (ranked 4th), and participatory justice (ranked 5th) also play a major role in the analysis of the key topic areas. This supports the findings above regarding the key conceptual elements of environmental justice and climate justice in the literature surveyed. Environmental risk (ranked 3rd) and intergenerational justice (ranked 6th) are also mentioned in multiple publications; as explained below, together with distributive, recognition, and participatory justice, they represent concepts that cut across two or more key topic areas. As observed above, non-anthropocentrism (ranked 7th), virtue ethics (ranked 11th), and eco-feminism (ranked 12th) play an important role in the conceptualisation of environmental ethics, and responsible research and innovation (ranked 10th) and responsible innovation (ranked 14th) were central in the conceptualisation of research ethics and integrity.

There are also similarities here with D1.3, as risk and justice were the second and third most frequent concepts mentioned in training materials; however, more specific instances of these concepts, such as environmental risk and distributive justice, were however referred to much more infrequently; intergenerational, participatory, and recognition justice were not even mentioned (Tzouvaras et al. 2025).

Relations between Key Topic Areas

This section investigates how the key topic areas conceptualised in the previous section relate with each other. A bibliometric mapping of the reviewed studies is shown in figure 9, based on the most frequently mentioned terms, using the VOSViewer software.

Figure 9: Bibliometric mapping of the studies reviewed



The 5 main clusters based on keywords occurrences are environmental justice (red), environmental ethics (purple), climate ethics (blue), research ethics and integrity (blue), and philosophy of technology (yellow). These clusters were created from the default key topic areas reviewers could choose from in the data extraction template at the third stage of the reviewing process. To these default options, reviewers could add other key topics covered in the studies; the topics that occurred more than once are also displayed in the figure (e.g., circular economy, ethics of geoengineering, energy justice). The larger the node, the higher the number of occurrences of the concepts in the reviewed literature (e.g., 54 occurrences for environmental justice, 35 for environmental ethics, 20 for climate justice). The concepts that are directly connected in the same cluster co-occurred in a least two papers (e.g., circular economy with RRI, ethics of geoengineering with climate ethics, energy justice with environmental justice); this also applies to concepts that co-occurred in different clusters (e.g., ethics of geoengineering and RRI, environmental justice and circular economy, ethics of geoengineering and philosophy of technology). The stronger the link between two concepts, the thicker the line that is used to display the link in the visualization. Environmental justice, climate justice, ethics of geoengineering, and climate ethics have a total of 6 links each, showing that they are highly interconnected concepts; environmental risk and philosophy of technology have a total of 5

links, and research ethics and integrity and RRI have 4 links, showing they are more moderately interconnected; the other concepts played a smaller role in connecting the key topic areas between themselves.

The resulting network shows that environmental justice and climate justice are connected directly, but also indirectly through energy justice (meaning that energy justice can serve as a link between the two concepts). Interestingly, environmental justice and environmental ethics are not directly connected to research ethics and integrity, but indirectly through the notion of “environmental risk.” Environmental justice is however directly connected to the notion of “circular economy,” which is part of the research ethics and integrity cluster. Climate ethics and the ethics of geoengineering are both directly connected to research ethics and integrity and responsible research and innovation; the ethics of geoengineering is also connecting climate justice with research ethics and integrity and responsible research and innovation. This shows that environmental risk, the ethics of geoengineering and circular economy play an important role in connecting the different key topic areas. Philosophy of technology connects climate ethics and the ethics of geoengineering to environmental ethics; environmental justice and philosophy of technology are however indirectly connected through the notions of “risk” and “resilience”. Corporate environmental ethics appears as separate from the rest of the network, which illustrates its disconnection from the topics and fields discussed in this review.

Figure 9 does not directly provide cross-cutting concepts between the key topic areas; it rather helps to see how often these topic areas are mentioned are how they are interconnected. To find cross-cutting concepts, it was necessary to look in more detail in the data extracted from the studies, and sometimes to go back to the text of the studies themselves to get more specific information. It was also necessary to interpret some of the findings displayed in this section, especially those related to the conceptualisation of the key topic areas. This more detailed analysis is the object of the next section.

3. Discussion

Cross-cutting concepts

Finding cross-cutting concepts in environmental ethics, climate ethics, and research ethics and integrity was one of the main objectives of our review. In this sub-section, we define and discuss the main cross-cutting concepts we found; we also provide illustrations of how they are used in the literature.

For a concept to be cross-cutting, it needs to meet the three following criteria: (1) relevance across key topic areas (the concept appears and is used in the analysis in more than one topic area); (2) capacity to bridge different knowledge domains (the concept helps integrate the issues and topics discussed in different research fields); and (3) transferability (the concept can be adapted and used to frame research questions in different research fields, even if it is not defined in the same way).

Table 6 displays the cross-cutting concepts found in the review, together with their number of mentions.

Table 6: cross-cutting concepts, based on their mentions

Cross-cutting concept	Key topic areas	Mentions
Distributive justice	Environmental justice and climate justice	54
Procedural justice	Environmental justice and climate justice	22
Recognition justice	Environmental justice and climate justice	23
Intergenerational justice	Environmental justice and climate justice	19
Polluter-pays principle	Environmental justice and climate justice	12
Indigenous perspectives or traditions	Environmental justice and climate justice	10
Energy justice	Environmental justice and climate justice	10
Restorative justice	Environmental justice and climate justice	8

Feminism	Environmental justice and climate justice	6
Responsibility	Environmental ethics/justice, climate ethics/justice and research ethics and integrity	59
Precautionary principle	Environmental ethics/justice, climate ethics/justice and research ethics and integrity	15
Geoengineering	Environmental ethics/justice, climate ethics/justice and research ethics and integrity	14
Citizenship	Environmental ethics/justice, climate ethics/justice and research ethics and integrity	8
Epistemic justice	Environmental ethics/justice, climate ethics/justice and research ethics and integrity	3

As the table shows, there are more cross-cutting concepts between environmental justice and climate justice than between environmental ethics/justice, climate ethics/justice, and research ethics and integrity. Also, most of the cross-cutting concepts in the first category are more often mentioned in the literature than the cross-cutting concepts in the second category. The notions of “responsibility”, “precautionary principle”, and “geoengineering” appear as the most important cross-cutting concepts across all the key topic areas.

Environmental justice and climate justice

As clearly illustrated by tables 3 and 5 above, environmental justice and climate justice overlap particularly on four forms of justice, which represent four major cross-cutting concepts:

- **Distributive justice:** both environmental and climate justice focus on the fair distribution of environmental and climate burdens, ensuring that marginalized people and communities do not bear disproportionate environmental and climate risks and harms.
- **Procedural justice:** both environmental and climate justice emphasize the importance of inclusive and fair decision-making processes, ensuring that all stakeholders, especially marginalized groups, have a voice in environmental and climate-related decisions.
- **Recognition justice:** both environmental and climate justice acknowledge the need to recognize and respect the identities, experiences, and rights of marginalized communities, including Indigenous peoples, in environmental and climate justice frameworks.

- **Restorative justice:** both environmental and climate justice address historic injustices caused by past environmental and climate endangering economic activities, such as extractivism, and aim to redress harms and damages caused by these activities and their long-lasting effects.

For instance, Karki et al. (2023) develop an approach to land-based mitigation technologies (LMTs) that links (socio-)environmental justice with climate justice through distributive justice. They stress that LMT implementation can lead to an increase in inequalities within communities, thereby exacerbating their vulnerabilities. For this reason, they support that “LMT interventions should focus on prioritising protection of rights of the marginalised people and indigenous communities, as well as enhancement of their livelihoods while simultaneously achieving multiple benefits from land use, such as climate change mitigation and various ecosystem services” (Karki et al. 2023: 19–20).

A fifth cross-cutting notion is **intergenerational justice**. This is not surprising, as the much-discussed definition of sustainable development provided by the Brundtland report relies on a specific conception of intergenerational justice: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (WCED, 1987, cited in Briggie, 2009). Much of the discussion in environmental justice and climate justice is about the specifications of the responsibilities we have towards future generations, typically in terms of distributive justice, with the idea that environmental benefits and burdens (especially environmental risks and hazards, but also the risks raised by environmental and climate technologies such as geoengineering) should be distributed fairly across generations. “Sustainability” could not be considered as a cross-cutting concept in this review, even if it was so frequently mentioned, as the definition of this notion remained too vague in the included literature, which mainly uses “sustainable” as an adjective to refer to more environmental-friendly policies, technologies, or practices; however intergenerational justice can be considered as the component of sustainability that was the most commonly used in the approaches developed in the included literature.

A sixth cross-cutting concept is the **polluter-pays principle**. The idea that individual, but mostly collective agents should pay for the consequences of their polluting activities is very common in the environmental justice and climate justice literature. The polluter-pays is a principle of distributive climate justice supporting that emitters must pay because of their past and present contribution to climate change (Ciplet & Roberts, 2017). As Popke et al. (2016, p. 71) stress, the polluter-pays principle has a strong backward-looking component to attribute responsibilities to address climate change; it is based on the fact that “some countries, because of their historical development trajectories and levels of technology, have contributed much more than others to the increased greenhouse gas emissions that are driving human-induced climate change.”

A seventh cross-cutting topic in environmental and climate justice literatures was **indigenous perspectives or traditions**. The studies reviewed did not cite standard definitions of what made something an Indigenous perspective, but had in common an emphasis on the embeddedness of nature and culture in the local territory, denying the divide between humanity and nature, and even humans and non-humans. Nonetheless, the indigenous and decolonial perspective of the philosopher Kyle Powys Whyte (2017, 2018) informed 4 of these studies. More considerations on indigenous perspectives are discussed in the next subsection in relation to epistemic justice.

An eighth notion that links environmental justice with climate justice is **energy justice**. This research field focuses on the justice-related issues raised by the energy transition and aims to find the conditions for a “just transition”. The most common understanding of energy justice came from Sovacool and Dworkin (2014), which was cited in 4 studies. This defines an energy-just world as a world “that equitably shares both the benefits and burdens involved in the production and consumption of energy services, as well as one that is fair in how it treats people and communities in energy decision-making” (Sovacool & Dworkin, 2014, cited in Kim et al., 2022, p. 24) (cited by Kim 2022, 24). Other understandings of energy justice came from Heffron and McCauley (Heffron, 2022; Heffron & McCauley, 2017; McCauley & Heffron, 2018) and Jenkins et al. (2016), which were cited in 2 studies. Interestingly, energy justice was more commonly understood in terms of Schlosberg's general view of environmental justice. The transition to a post-carbon society is based on three conceptual pillars that were identical to those of environmental justice (Lloro-Bidart & Finewood, 2018; Roe & Zavar, 2021; Stephens, 2024), namely distributive justice, procedural justice, and restorative justice. This suggests that energy justice may not be conceptually distinct from environmental justice, at least in the publications analyzed in this review.

A last cross-cutting concept, which is more of a theory, is that of **feminism**. This approach highlights the gendered nature of both environmental and climate injustices and calls for gender diversity and equality in environmental and climate decision-making. For instance, *feminist climate justice* focuses on the reproduction and exacerbation of gender inequities through climate policies decision-making, encouraging instead greater gender diversity in climate and energy leadership for transformative social change (Stephens, 2024). A second example is *intersectional feminism*, which explains that social inequalities in terms of sexism, racism, and classism, and environmental inequalities in terms of air, land, and water pollution are often closely intertwined (Lloro-Bidart & Finewood, 2018). In this context, intersectionality is defined as a “theory and approach of studying the relationships amongst numerous dimensions of social relationships, subject formations, and categories of power” (Hovorka, 2015, cited in Lloro-Bidart & Finewood, 2018). Intersectional feminism is closely related to *eco-feminism*, which focuses on the human-landscape relation and explains how a lack of emphasis on that relation can result in the devastation of land and the displacement of people. While not all discussions of ecofeminism cited their understandings, the critical perspective on human/nature dualism of ecofeminist theorist Val Plumwood (1988, 2003, 2008) was cited 3 times in this literature.

Environmental ethics/justice, climate ethics/justice, and research ethics and integrity

Finding cross-cutting concepts between environmental ethics/justice, climate ethics/justice, and research ethics proved to be challenging. This is due to the research gap between these key topic areas mentioned in the previous section. Only three major cross-cutting concepts were found, with two other cross-cutting concepts that played a more limited role in linking the key topic areas, but that could contribute to further bridging the research gap if developed in future research.

Responsibility appears as the most important cross-cutting concept of our review. It plays a central role in environmental justice and climate justice, where the allocation of responsibility to address climate change and other environmental issues such as biodiversity loss represents a major research question. In this context, the polluter-pays principle, the ability to pay principle, and the beneficiary pays principle, are often discussed to find a fair allocation of climatic or environmental responsibilities. Responsibility is often used in the context of research ethics, where RRI plays an important role. Purvis et al. (2023) discusses the framework for RRI adopted by the EU in 2014 for the Horizon 2020 research funding programme, which is based on six pillars: ethics, governance, gender equality, open access, public engagement, and science education. They stress that “The number of women involved in research groups, open access papers, the compliance to institutional ethical procedures, or conduction of public engagement exercises are all very important activities but do not guarantee that research is conducted responsibly” (Purvis et al., 2023, p. 3). For this reason, they recommend focusing on the AIRR framework as the main guiding principles to guide a just transition to a circular economy, which is based on the core values of anticipation, inclusion, reflexivity, and responsiveness. This AIRR framework is referred to as the “UK tradition of Responsible Innovation” (Purvis et al., 2023, p. 3). Interestingly, this framework is meant to ensure that the transition to a circular economy addresses social, ethical, and environmental justice concerns, thereby articulating research ethics with environmental justice. The value of inclusion plays an important role in this articulation; the authors stress the importance of not creating or exacerbating existing injustices in the transition to circular economy, such as the lack of inclusion of groups disproportionately affected by environmental hazards, including minority ethnic groups and low-income communities, in the decision-making process.

A second major cross cutting topic is the **precautionary principle**. Mentions of the precautionary principle were most common in environmental ethics (7 mentions), with 3 mentions in relation to environmental justice, 2 mentions in relation to research ethics and integrity, and 2 mentions in relation to climate justice (1 additional mention was unaffiliated with these discourses). The precautionary principle also featured in studies on RRI, and environmental risk. In this context, the notion of “systemic risk” was sometimes used to refer to risks that endanger the functioning of vital systems such as infrastructure, supply chains, and healthcare systems (Hofbauer, 2023; Yearley, 2009). Alario and Freudenburg (2010) also introduced the concept of “Titanic risk” to complement the understanding of “risk society” as developed by Giddens (1997) and Beck (2007) to highlight that technological risks, such as toxic waste, nuclear technologies, and climate impacts, fundamentally reflect problems of inequity and inequality, in line with environmental justice concerns. They stress, “climate disruption is clearly having its most severe consequences for the poorest of the global poor, particularly women, children, and the residents of polar regions and small inland states” (Alario & Freudenburg, 2010, p. 508).

A third major cross-cutting concept is **geoengineering**, which covers both solar radiation management (SRM) and carbon dioxide removal (CDR). Geoengineering is defined as “deliberate large-scale manipulation of the planetary environment to counteract anthropogenic climate change” (Royal Society, 2009, cited in Muraca & Neuber, 2018; Pamplany et al., 2020). The conceptualisation of this object of research is itself a topic of debate, with some authors using “geoengineering” (e.g., Pamplany et al., 2020), others using “climate engineering” (e.g., Brooks

et al., 2022), and others still using more specific categories, such as “land-based mitigation technologies (LMTs)” (Karki et al., 2023) or “negative emissions technologies (NETs)” (Mintz-Woo, 2023). The ethics of geoengineering, a sub-field of climate ethics, focuses primarily upon the ethical and governance challenges of research into geoengineering techniques. It is clearly linked to research ethics, with two opposite approaches on research into geoengineering in the literature reviewed by Pamplany et al. (2020). On the one hand, some scholars support the idea that research into geoengineering to make these techniques ready for deployment in an emergency has become necessary, especially to minimise risks, reduce uncertainties, and reduce the side-effects of geoengineering techniques on the poor. On the other hand, other scholars find research into geoengineering to be intrinsically unjustifiable, typically due to the absence of legitimate governance, lack of political preparedness, the difficulty to obtain the informed consent of all those who will be exposed to side-effects, and the risk of research inevitably leading to implementation (the so-called slippery-slope argument). The precautionary principle has been invoked by different authors to raise concerns over field tests, some even calling for a moratorium on research and development of geoengineering techniques. Some authors have also approached geoengineering from an environmental ethics perspective, citing concerns over the risks linked to the project to dominate nature by “playing God” with the climate system, and the consequences this might have on the value of this system, as well as aesthetic concerns due to changes in appearance of sunsets or blue skies.

Most of these concerns apply to SRM, but an emerging literature focuses on CDR, NETs, and/or LMTs. In a perspective relevant for research ethics, Nawaz and Satterfield (2024) list criteria that CDR projects should follow to conduct “justice and robust social research”: conduct engagement with potentially affected communities to understand their views and give them opportunities for meaningful engagement; make explicit commitments for integrating the findings of these engagement efforts into research and planning efforts, making explicit the conditions under which research will or will not move forward; make explicit commitments to obtain consent from Indigenous peoples; explore the potential for benefits that empower local communities; and make formal positions on moving away from fossil fuel funding and ownership to guarantee the independence of carbon removal systems. Mintz-Woo (2023) considers where we should devote resources to developing NETs, highlighting a trade-off between the regions with the best mitigation potentials from deployment (especially Asian countries) and the regions with the greatest need for carbon removal (typically Western-industrialised countries). Karki et al. (2023) review ethical barriers to LMTs and discuss trade-offs in terms of land availability and competition with other land uses, noting risks of increasing food prices and food insecurity, along with risks of land grabbing, inequitable sharing of benefits and negative effects on vulnerable groups lacking access or secure land rights, including women, minority groups, and Indigenous peoples. Bringing together climate justice and environmental justice considerations, the authors define the concept of “land-based mitigation injustice” as an “increase in inequalities within communities and exacerbating their vulnerabilities as a result of LMT implementation, which involves land-based actions for removal of carbon from the atmosphere or reduction of GHG emissions” (Karki et al., 2023, pp. 19–20). Finally, 3 studies mentioned ethical issues reviewed by Lenzi (2018), such as the problem of technological, economic, or biological infeasibility of some NETs; their unacceptable impacts on biodiversity, food security, water resources, and human rights; the reversal risks due to human actions and

natural forces disturbing reservoirs of carbon; and the problem of irreversible climate impacts during the overshoot period (Bourban, 2022; Clingerman, 2022; Mintz-Woo, 2023).

The review also identified several less prominent cross-cutting topics, which nonetheless appeared to reveal conceptual overlaps between environmental ethics/justice, climate ethics/justice, and research ethics. One was **epistemic justice**, with one mention in research ethics and integrity (Arancio, 2023) and two mentions in papers discussing both climate ethics/justice and environmental ethics/justice (Bush & Doyon, 2023; Mabon & Shackley, 2015). Epistemic justice supports the protection and incorporation of Indigenous knowledge, languages, stories, and songs into environmental policies. Epistemic justice is defined as a call for “alternative forms of being and seeing the world to be recognised as valid and valuable knowledge and includes the even greater challenge of translating this into real policy and practice and social justice” (Temper, 2019, p. 106, cited in Bush & Doyon, 2023). Interestingly, epistemic justice is framed as a complement to distributive, procedural, and recognition justice, which highlights the need to go beyond the traditional approach to environmental justice to link this topic area with research ethics and integrity. For instance, it goes beyond procedural justice, because even if fair procedures are in place, epistemic injustices are still possible, as people can still feel marginalised in deciding which question to ask or how to frame the question because of their social identity, knowledge, and access to accepted cognitive frameworks, or because they do not speak in the dominant language used in the decision-making process. As Mabon and Shackley (2015, p. 471) stress, “We see epistemic justice as particularly important for energy and climate change because the huge uncertainties involved – and potential for profound effects on peoples' lives – mean governance based on 'hard science' alone may struggle to encompass the range of concerns”. Epistemic justice is also implicitly relied upon in two studies that utilise the notion of *transformational climate justice* (Forsyth & McDermott, 2022; Kinol et al., 2023). Focused on power dynamics, this approach proposes rethinking the knowledge processes used in climate science to promote participatory and inclusive forms of knowledge generation. It is based on collaborative efforts between academic and non-academic partners, and includes co-producing climate justice knowledge through community partnerships, expanding international, global research partnerships particularly among interdisciplinary teams in the global north and global south, and growing intergenerational research such as early career and graduate training opportunities.

Related to the concept of epistemic justice, the use of both digital and agricultural technologies in the context of biological conservation and climate policies was discussed in several studies. Starting with *digital technologies*, 3 studies stress that the use of technologies collecting data need to be implemented by respecting the rights of local and indigenous people, including their rights to privacy, autonomy, (data) sovereignty, and (intellectual) property (Bettini et al., 2020; Cifuentes, 2023; Parris-Piper et al., 2023). This includes typically the use of smart earth technologies monitoring and tracking environmental degradation, such as forest monitoring programs, drones, and satellite images. These studies also stress the importance of including local and indigenous people in the decision-making process on how to implement these technologies. In this context, Bettini et al. (2020) put forward the notion of “digital justice”, which is also defined by relying on distributive justice (the allocation of burdens and benefits related to the use of digital technologies), participatory justice (participation in the definition of policies relying on these technologies), and recognition justice (the recognition of the interests of the

different stakeholders involved in the application of these technologies). Parris-Piper et al. (2023) propose the notion of “automated violence” to refer to smart technologies in forest governance that restrict Indigenous and local people’s access and right to forest resources and land, thereby exacerbating social injustices against historically marginalised groups. Three other studies stress the importance of incorporating local and traditional knowledge into the design and application of *agricultural technologies* (Orozco-Meléndez & Paneque-Gálvez, 2022; Popke et al., 2016; Shaw & Wilson, 2020). For instance, Orozco-Meléndez and Paneque-Gálvez (2022, p. 2) focus on “grassroots innovations”, conceived as “innovations created by individuals or collectives from indigenous or peasant communities or organizations, which generate new social or technological solutions based—at least parti-ally—on local or traditional knowledge, to satisfy their social and environmental needs”. Examples of grassroots innovations in the context of agroecology include innovations aimed at maintaining the sovereignty of Indigenous and local people’s means of production and cultural reproduction, innovations to protect their natural heritage and innovations to improve community health and education.

A second cross-cutting concept that played a minor role but could play an important role in future research is the one of **citizenship**. A first relevant application of this notion is the one of *citizen science*, a strategy for environmental protection that allows for the incorporation of environmental justice concerns from populations exposed to environmental hazards (Perovich et al., 2018; Scott & Barnett, 2009; Shulman et al., 2005; Wyeth, 2023). Citizen science, also referred to as “civic science” or “scientific citizenship”, engages the public in collecting scientific data, asking research questions, and finding patterns, for instance by monitoring air quality. This allows the incorporation of societal concerns into future assessment and regulation of technological innovation, for instance through hybrid knowledge production combining scientific knowledge and knowledge from lay communities, with lay knowledge being conceived as local, nonscientific, hard earned, less formally organized, and related to self-identity (Scott & Barnett, 2009).

On behalf of the EPA, the Environmental Law Institute (ELI) examined how citizen science was being used or supported by environmental agencies in states, tribes, and local governments in the USA (Wyeth, 2023). ELI recommends that agencies recognise and harness the value of citizen science, that they establish leadership hubs for coordination and information sharing, that they take a proactive approach in working with environmental justice communities to make their data gathering efforts impactful, that they help citizen scientists generate high-quality data that is likely to be useful, and that they coordinate the sharing of data management systems and practices.

In its report “Best Practices in Citizen Science for Environmental Monitoring”, the European Commission (2020) makes recommendations in four major areas: matchmaking between knowledge needs for environmental policy and citizen science activities; promoting awareness, recognition and trust; promoting data quality and interoperability standards and sharing tools; and supporting coordination and cooperation for policy impact. Wyeth (2023, p. 10) stresses that despite the lack of coordination between the EC and the ELI/EPA, there are remarkable similarities, which “... suggest that citizen science is at the same stage of development globally in its potential to inform and be used in policymaking.” In particular, a barrier faced by EU and US agencies is uncertainty about what to make of data from nontraditional sources: there is a problem of confidence in the citizen scientist’s approach and the quality of the data provided

by this approach. As a response to this issue, both the EC and the ELI/EPA stress the idea of “matchmaking,” or “meeting the citizen scientists halfway”: the process of identifying the questions and decisions that citizen-generated data can be relevant to, and setting out guidelines and protocols for what needs to be done to make the data acceptable for those uses. While this process requires action by agencies, increased coordination and cooperation can be initiated by citizen scientists themselves, for instance by creating channels and platforms for sharing experiences, building common practices, and continuously improving the state of the art.

A second relevant application of the notion of citizenship is the one of *environmental or ecological citizenship* (Bourban, 2022; Karlsson, 2012; Symons & Karlsson, 2018; Wong & Sharp, 2009). Environmental citizenship aims to reconcile environmental policy objectives with democratic commitments by prompting individuals to voluntarily choose more sustainable lifestyles and support collective efforts to protect the environment. Environmental citizenship therefore occurs in both public and private spaces, as it is related both to the support for and adoption of more ambitious environmental policies, and the support for and adoption of more sustainable behaviours, based on individuals’ values and attitudes. In this view, the just transition to more sustainable societies is not only based on structurally oriented approaches, but also on voluntary shifts in lifestyles. This connects citizenship theory with environmental virtue ethics, as the attitudes leading to lifestyle changes can be values such as temperance, simplicity, and energy sobriety, character traits that typically imply decreased consumption of highly emitting goods and services. Environmental citizenship is also related to climate ethics, specifically the sub-field of individual climate ethics, which focuses on individuals’ duties to reduce their carbon footprint and to promote collective action through active citizenship.

An overview of all the cross-cutting concepts found in the review appears in figure 10.

Figure 10: Venn diagram of cross-cutting concepts

Environmental justice and climate justice

Research ethics and integrity



Environmental ethics/justice, climate ethics/justice, and research ethics/integrity

It is also informative to compare our analysis of the cross-cutting concepts in the academic literature with the findings of D1.3 (Tzouvaras et al. 2025). Responsibility was also a key concept in the reviewed training resources, with 12.6% of the materials and 23% of the programmes referring to the principle of responsibility, in the context of responsible conduct of research. However, the precautionary principle was only mentioned once, and the polluter-pays principle was not even mentioned in the training resources. Turning to the research ethics and research integrity guidelines and frameworks reviewed in D1.3, responsibility was also the most frequently mentioned principle, appearing in 39.4% of the documents; citizenship also played an important role and was often linked to responsibility, as the key theme of “environmental responsibility and citizen participation” was addressed in 13.6% of the reviewed documents, with a focus on the relevance of citizen science in informing environmental policy. In addition to this, the precautionary principle was mentioned in 8.9% of the included guidelines and frameworks, and intergenerational justice and distributive justice were both mentioned in 5.2% of the documents. This shows that responsibility, the precautionary principle, citizenship, and justice (especially distributive justice and intergenerational justice), are not only important in connecting the key topic areas in the academic literature, but also in training materials and programmes and in research ethics and integrity guidelines and frameworks.

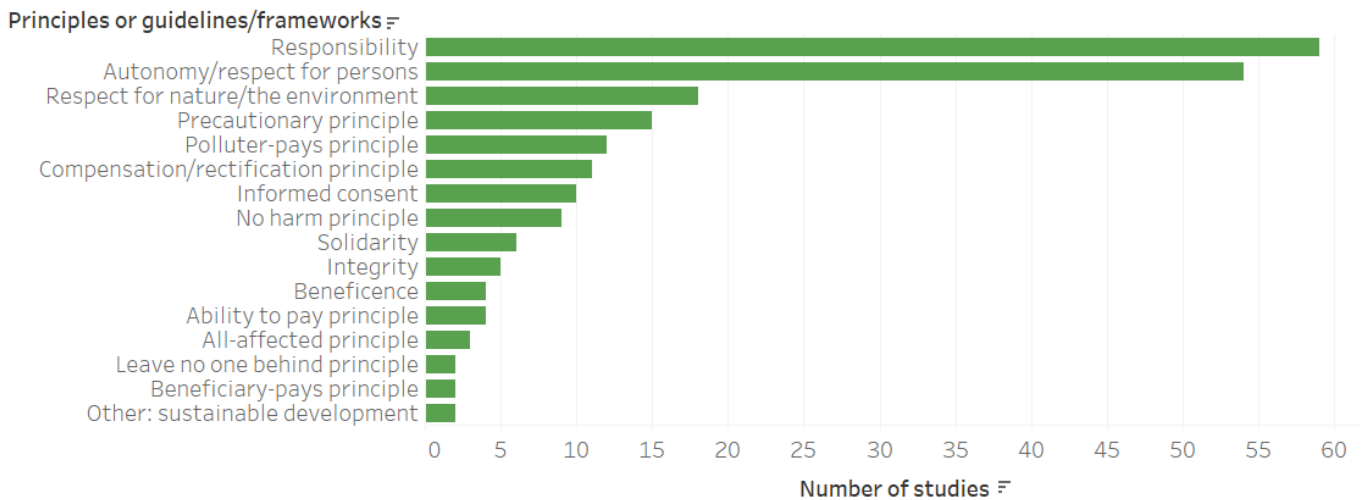
Guidelines, Frameworks, and Principles

This section discusses the guidelines and frameworks mentioned in the studies that have been reviewed. It starts with more general considerations on the most discussed ethical principles

and values that should guide the design, development, and deployment of technologies involved in the green transition and then focuses more specifically on the frameworks and guidelines explicitly mentioned in the literature.

Figure 11 provides an overview of the most discussed principles and values in the literature (the figure displays principles and values that are mentioned at least more than once).

Figure 11: Principles or guidelines/frameworks mentioned in studies



The two values that are by far the most influential in the selected literature are responsibility (37.8%) and autonomy or respect for persons (34.6%). This is probably because responsibility and autonomy can have many different meanings and can be applied in many different contexts. As discussed above, **responsibility** represents a major cross-cutting concept in the reviewed literature, and is linked to the **polluter-pays principle** (7.7%), the **ability to pay principle** (2.6%), and the **beneficiary pays principle** (1.3%), which aim to allocate responsibility to different individual and collective agents, especially nation-states.

Autonomy is often mentioned in the bioethics literature included in this review. **Bhardwaj (2006: 170)** conceives autonomy as the “guiding principle for recognition of human capacity for self-determination and independency in decision-making”. It is mentioned alongside other bioethics principles, such as **beneficence** (the intention to do good and the practice of good deeds) (2.6%), non-maleficence (the obligation not to inflict harm), and justice (fair treatment and equity). There is a fair degree of overlap with the literature on environmental justice and climate justice, as harm-avoidance justice (Bourban 2022) and non-maleficence are both based on the **no harm principle** (5.8%), which could be extended to environmental harms (**Vaishnav 2023**), and justice as fair treatment is very close to procedural or participatory justice.

Two other major principles displayed in figure 11 are the **precautionary principle** (9.6%), another major cross-cutting concept discussed above, and **respect for nature or the environment** (11.5%), which is often conceived as a character trait that agents ought to adopt to live a virtuous life in the literature on environmental virtue ethics.

Table 7 compare these findings with those of **Tzouvaras et al. (2025)** in D1.3.

Table 7: Comparison of principles reviewed in D1.1 and D1.3

Principle	Occurrence in academic literature	Occurrence in guidelines and frameworks	Occurrence in training materials	Occurrence in training programmes
Responsibility	37.8%	39.4%	12.6%	23.9%
Autonomy/Respect for persons	34.6%	17.8%	2.5%	4%
Respect of nature or the environment	11.5%	21.6%	6.7% (only for "respect")	7.2% (only for "respect")
Precautionary principle	9.6%	8.9%	0.8%	0%
Polluter-pays principle	7.7%	0.9%	0%	0%
Compensation/rectification principle	7%	3.8%	0%	1.2%
Informed consent	6.4%	19.6%	1.7%	0.8%
No harm principle	5.8%	3.3%	0.8%	0.4%
Solidarity	3.8%	8.9%	2.5%	0.8%
Integrity	3.2%	35.2%	3.4%	13.1%
Beneficence	2.6%	8.9%	0%	0%
Ability to pay principle	2.6%	0%	0%	0%
All-affected principle	1.9%	0%	0%	0%
Leave non-one behind principle	1.3%	0%	0%	0.4%
Beneficiary-pays principle	1.3%	0%	0%	0%

As mentioned in the previous sub-section when discussing cross-cutting concepts, responsibility emerges as a major principle; the same applies to the precautionary principle (with the exception of training resources). Interestingly, this table also allows to draw attention to new principles and values that did not emerge as cross-cutting concepts in the reviewed literature, such as autonomy or respect for persons, respect for nature or the environment, integrity, solidarity, the no harm principle, and informed consent, all of which are mentioned across the different documents reviewed in D1.1 and D1.3. This suggests that these notions have the potential to play the role of cross-cutting concepts in future research. It is also interesting to note the discrepancies in this table, for instance with the polluter-pays principle playing a non-negligible role in the academic literature but almost no role in guidelines and principles and no role at all in training resources, or integrity playing a minor role in the academic literature but a much more important role in guidelines and principles and training programmes. This shows that while these different resources all tend to focus on responsibility, autonomy, and respect for nature, they do not give the same degree of importance to other principles and values such as the precautionary principle, the polluter-pays principle, and integrity.

Table 8 provides an overview of the guidelines and framework explicitly discussed in the selected literature, based on the category of technology to which they are applied.

Table 8: Guidelines, Frameworks and Principles in Relation to Categories of Technology

Category of technology	Guidelines, Frameworks, and Principles discussed	References
Technologies relying on critical raw materials	<ul style="list-style-type: none"> - The <i>2018 Report on Critical Raw Materials and the Circular Economy</i> (European Commission 2018), which highlights potential for critical raw materials (CRMs) in the circular economy as part of an EU renewed industrial strategy and the EU Circular Economy Action Plan under the 2016 Clean Energy Package centered on the EU economy's energy transition. CRMs represent materials that are irreplaceable in clean technologies such as solar panels, wind turbines, electric vehicles, and energy-efficient lightning. - The <i>OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas</i> (OECD Guidance, 2011, 2013), which advises on due diligence in supply chains for all minerals globally. 	(Hancock et al., 2018)
Energy technologies	<ul style="list-style-type: none"> - The <i>Green New Deal framework</i>, which is composed of five key interlinking topical areas: emissions mitigations, education and labor, infrastructure, health and healthcare, and social equity. 	(Kinol et al., 2023)

	<ul style="list-style-type: none"> - The Green New Deal can and should be complemented with the <i>Energy Democracy framework</i>, which focuses on resisting concentrated and centralized fossil fuel-based powers, restructuring power systems to encourage and support distributed renewable power, and reclaiming decision-making in energy systems for the public good. 	
Geoengineering technologies	<ul style="list-style-type: none"> - The <i>Institute for Advanced Sustainability Studies (IASS) working paper "An Exploration of a Code of Conduct for Responsible Scientific Research involving Geoengineering"</i>, a draft Code of Conduct contributing to the establishment of principles and procedures applicable to geoengineering, in accordance with international law, taking into account all relevant environmental, scientific, technological, economic, social, and cultural concerns (Hubert and Reichwein 2015). - The <i>Oxford Principles</i> (Rayner et al. 2013), which consider research on climate technologies as public good, and that it should therefore of benefit to all of humankind. These principles also promote public participation in decision-making, the public disclosure of the results of conducted research, and independent assessment of impacts and effective governance before deployment. This ethics of geoengineering framework is criticized by Fulvi (2023) because even if all known risks raised by geoengineering could be minimized, there would still be relevant unknown risks. - Ethical codes, frameworks, and guidelines on geoengineering have a strong emphasis on the principles of autonomy, freedom, integrity, human rights, and privacy; however, Brooks et al. 2022 stress that dignity and trust tend to be marginalized or neglected in the developmental process of geoengineering. 	(Brooks et al., 2022; Fulvi & Wodak, 2023; Low & Buck, 2020)
Agricultural technologies	<ul style="list-style-type: none"> - <i>Ethics of Modern Developments in Agricultural Technologies</i>, a report by The European Group on Ethics in Science and New Technologies to the European Commission (EGE 2008), which provides ethical guidelines for the production and distribution of agricultural plant-based technologies, and guidelines for policymaking in agriculture. Food security, food safety, and sustainability represent the first priorities and guiding principles. The authors recommend increased EU funding for the agricultural sciences, green biotechnologies and all other sustainability-oriented agriculture research sectors. - The Alliance for Food Sovereignty in Africa (AFSA) considers that the principle of food security is overly limited; it supports the principle of food sovereignty, 	(Biddle, 2017)

	<p>which emphasizes local autonomy, including control over labor practices, agricultural methods, and how food is conceptualized, than food security. Food security, understood as access to safe and appropriate food, could be supplemented with food sovereignty, which represents a plausible additional guideline for RRI in agricultural technology.</p>	
Space technologies	<ul style="list-style-type: none"> - <i>UN Principles Relating to Remote Sensing of the Earth from Space (UN 1986)</i>, which include many ethical statements, such as gaining the benefits of remote sensing for all countries (Principles II, IV, and VI), accordance with international law (Principle III), and the promotion of international cooperation (Principles V and VIII). The principles also encompass environmental impact in Principle X, which foresees the use of remote sensing to 'promote the protection of the Earth's natural environment'. - More generally, <i>Biasetti (2023)</i> stress that general ethical principles for the different uses of space technologies include autonomy, fairness, and well-being, including environmental well-being, which can be promoted by biodiversity conservation applications of space technologies, but also threatened by space debris causing pollution in space and on Earth. 	(Biasetti & Grigoletto, 2023; Harris, 2013)

Recommendations

This subsection provides a review of the recommendations for researchers, educators, and policymakers that were provided in the reviewed studies. Only recommendations that are explicitly framed as such are included below. We only included the most discussed recommendations and some representative examples of these recommendations.

For researchers

In line with the demands of **participatory justice**, several studies call for more participatory research in the design and implementation of climate and environmental technologies and policies, especially through the development of fair and responsible processes to include all relevant stakeholders at local, national, regional, and global levels that represent a diversity of viewpoints and interests (Bailey 2012, Chiles 2018, Forsyth 2022, Hope 2014, Levenda 2021, Kinol 2023, Karki 2023, Nawaz 2024, Low 2020, Ottinger 2011, Roe 2011, Hilser 2024, Stephens 2024).

A first important point made by *Roe and Zavar 2021* is that to include relevant stakeholders, we need to clearly identify the communities impacted by technological disasters, such as chemical spills, toxic waste contamination, nuclear radiation, transportation accidents, and factory

explosions. To do so, we need clearer definitions of expressions often used in the context of environmental hazards, such as “vulnerable populations”, “wrongdoing”, and “community”. To recognize the diversity of participants and experiences within affected communities, they argue for an expansion of environmental justice alongside ecofeminist principles.

In the context of the energy transition, [Levenda et al. 2021](#) stress that a major issue with large-scale renewable energy projects is that they often involve design and siting decisions that are made in far-off places, without including local communities or local knowledge. They recommend the integration of smaller scale renewable energy systems in renewable energy policies in order to allow for more localized benefits and decision-making.

In the context of transformational climate justice, [Kinol et al. \(2023\)](#) recommend that colleges and universities move away from traditional, siloed academic research and instead engage in new kinds of strategic collaborative relationships and partnerships with non-academic partners at multiple scales. New kinds of collaborations include “co-producing climate justice knowledge with community partnerships, expanding international, global research partnerships particularly among interdisciplinary teams in the global north and global south, and growing intergenerational research such as early career and graduate training opportunities, and cross-cutting curricula linking climate justice across disciplines, programs, departments, and schools”. ([Kinol et al. 2023: 21](#))

In the context of CDR, [Karki et al. 2023](#) recommend developing a novel integrated system approach, considering social and environmental goals for rapid scaling up of LMTs. Large-scale deployment of LMTs requires new multi-sectoral and multilevel governance system through a bottom-up and intercultural approach that takes into account Indigenous knowledge, local values, and cultural heritage and interests. [Nawaz and Statterfield \(2024\)](#) stress that marine CDR governance should place the interests, expectations, and concerns of coastal actors at its center: the views of the groups potentially affected by CDR governance projects should be included at all the major steps of the decision-making process, for instance by forming community working groups to collaborate on decision-making throughout each stage of project development. Projects should also clearly state how they will obtain meaningful consent from Indigenous peoples whose territories they will operate on, and explore the potential for project benefits that empower local communities. Similarly, [Low and Buck \(2020\)](#) call for researchers to engage into “mission-driven” research programs into CDR and SRM, through situated engagements that can take place at all levels in contexts that are locally meaningful, such as governmental settings, community centers, educational institutions, or religious organizations. Finally, [Hilser et al. 2024](#) encourage future research that investigates how participatory, democratic, localized governance and selective framing approaches may influence public attitudes toward CDR in more climate vulnerable communities, and to inform strategies to develop more inclusive and just CDR solutions.

More specifically related to epistemic justice, [Cifuentes \(2023\)](#) warns researchers using open-access data that these data might represent a treat to Indigenous people. Open-source data raises questions of who will set quality controls, and whose interests the data will serve. Opening data might raise concerns about protecting Indigenous cultural information, rights, and intellectual property. For the Global Indigenous Data Alliance, for instance, data sovereignty should include designing rules for the restriction and opening of data. Similarly, but more

specifically, [Macdonald et al. 2021](#) recommend using co-developed protocols to integrate Indigenous ethics and governance into research, and to adhere to CARE principles in data collection, sharing, and usage.

Other, more specific recommendations are listed in table 9, based on the category of researchers to which they apply.

Table 9: Recommendations for researchers

Category of researchers	Recommendation	References
Research ethicists	A revised system of research ethics application where the environmental impact of proposed medical trials is considered by applicants and committees prior to approval is recommended. In this context, the use of electronic formats and reduced reliance on paper is recommended.	Chakladar 2011
Environmental ethicists	Environmental ethicists should draw more on philosophy of technology, especially the technology assessment approach, which "advocates for the creation of government institutions designed to improve the ability of decision-makers to analyze the effects of technologies", and the alternative/intermediate technology approach, which "advocates for more concentrated efforts by individuals to engage in a thorough and exhaustive analysis of the impact of their own technological choices".	Gerrie 2003
Researchers working on geoengineering technologies	<p>By doing research into NETs, researchers should not endorse an outdated risk aversion mindset by critiquing the inherent riskiness of NETs, but advocate for an implementation that is socially equitable and beneficial for both the human and the more-than-human world. In the context of NETs, risk ethics may no longer restrict itself to the dangerous anthropogenic interference that gave rise to the climate crisis; it must instead turn toward the dangerous anthropogenic interventions of a climate change technofix</p> <p>Any Stratospheric Aerosol Injection research program needs to inherently and explicitly address the question of how it aims to deal with the risks it produces, such as mitigation deterrence effects, the risk of unilateral decision-making, and the unreflected inclusion and exclusion of different values.</p>	Fulvi 2023 , Hofbauer 2023 , Pamplany 2020

	<p>Researchers should resist the urge to ignore the distinctions between various geoengineering technologies and to lump everything under the umbrella label of "geoengineering". There is a need for more extensive research on geoengineering, both from an empirical and experimental perspective, especially on the impact of SRM on precipitation, on the feasibility of scaling up NETs, and on the impacts of both SRM and NETs on food production and food justice</p>	
<p>Researchers using CRMs</p>	<p>Universities' procurement policies could be linked to their sustainability policies by: considering human rights, ethical production processes, social justice, and recycled materials; promoting equity in the use of global resources; positively influencing supply chains and productive use of resources/materials; and asking suppliers about procedures supporting human and labor rights, anti-corruption, diversity and inclusiveness, environmental impact and health and safety. Universities can also look to recent international (OECD and EU) and national regulations (for example, the US Dodd Frank Act) on conflict minerals in supply chains, for principles and guidance on supply chain reporting.</p> <p>University/laboratory leaders need to also become aware of the threat-multiplier effect and ambiguities around critical materials for alternative energy research. Critical materials are not regulated like conflict minerals, but like all materials not mined responsibly, their production can lead to human rights abuses and other environmental, social and conflict impacts. In relation to equity, materials need to be assessed for their accessibility and affordability, if the transition to a zero carbon future is to be possible for developing countries and marginalized, remote or low socio-economic communities. Incorporating enhanced analyses of critical materials, as well as conflict minerals, into laboratory research and procurement is increasingly essential when such analyses are designed to help avoid supply chain impacts on human rights, to reduce local, regional and international conflicts, to guard against adversely affecting the environment and to optimize future supply. It may also add value to alternative energy research and innovation based on affordable, ubiquitous materials.</p>	<p>Hancock 2018</p>

Several papers reviewed also included recommendations for educators that can play a key role in promoting a just transition.

A first relevant approach put forward by Segovia (2009) is that of **education for sustainable development** (ESD), a vision of education that was part of an action plan formulated in the 1992 United Nations Conference on Environment and Development (UNCED). The four major thrusts of ESD as articulated in Agenda 21, Chapter 36 are:

1. Promoting and improving basic education;
2. Reorienting existing education at all levels to address sustainable development by including more principles, skills, perspectives, and values related to sustainability in each of the three pillars (social, environmental, and economic);
3. Developing public understanding and awareness of sustainability;
4. Developing specialized training programs in all economic sectors to ensure that the whole workforce has the knowledge and skills necessary to perform their work sustainably.

Based on this agenda, Segovia (2009, p. 751) recommends that ESD should be implemented the following way in schools:

1. Enable knowledge on sustainability to be incorporated into the curriculum by updating educational practice with recent research on sustainable development;
2. Conduct school-based longitudinal studies using student work samples to determine the impact of ESD curriculum on student-learning results;
3. Establish and strengthen an open-ended research agenda to inform and strengthen key areas of ESD practice in teacher education;
4. Establish and strengthen a vibrant community of practice in education, which strengthens the teaching and research capabilities of educators involved in ESD.

An example of ESD is the Dark Green School (DGS) project, an accreditation process by the Environmental Education Network of the Philippines, in which standards are set, and a review is undertaken to determine the level of greenness of an educational institution. The accreditation process investigates whether the following elements contribute to the promotion of sustainable development: (1) school policy; (2) administration and finance; (3) academics (which includes research); and (4) outreach. Segovia (2009, p. 752) stresses that if all educational institutions joined in this type of ESD initiative, students would learn the art of addressing issues as an interconnected system and not as fragmented problems with separate and often competing solutions: "The curriculum would inculcate an appreciation of the human-environment interdependence, making biocentric values and ethics a central part in all the disciplines, rather than offering them as special subject only for certain courses."

Next, as part of the **transformative climate justice** approach discussed above, Kinol et al. (2023) stress that universities and colleges could and should realign and redefine their priorities in teaching, research, and community engagement to shape a more just future. Rather than perpetuating the concentration of wealth and power by focusing on technological innovation and the financial success of alumni and the institution, colleges and universities can advance societal transformation toward climate justice, by teaching climate engagement, supporting impactful justice-centred research, embracing non-extractive hiring and purchasing practices, and integrating community-engaged climate justice innovations across campus operations. A large part of universities' contribution to a greener future would be a shift in curriculum and funding toward sustainability, climate justice and social justice education. To advance a just

transition away from climate injustices, the dominant knowledge paradigms on which current societal systems were built, such as approaches to academic knowledge production that maintain systemic racism, must be challenged. In particular, new strategic collaborative relationships and partnerships with non-academic partners are critical to expanding beyond traditional siloed academic work. These new collaborations include “co-producing climate justice knowledge with community partnerships, expanding international, global research partnerships particularly among interdisciplinary teams in the global north and global south, and growing intergenerational research such as early career and graduate training opportunities, and cross-cutting curricula linking climate justice across disciplines, programs, departments, and schools” (Kinol et al., 2023, p. 21).

More specifically, Goldman et al. (2014) stress that *engineers* should be equipped with an ecological perspective focused on human-nature interrelationships by adapting curricula towards multidisciplinary, integrative learning addressing social, political, economic, and ethical perspectives. They call for a “greening” of the engineering curriculum, with the aim to “educate students in their specific field of study in such a way that their subsequent professional work incorporates an environmental perspective and contributes to a more sustainable world” (Goldman et al., 2014, p. 326). In particular, engineering students should be trained in identifying and addressing value conflicts: value-based thinking is central in understanding human relationships with nature and making sustainability an integral component for engineering practice and education. This is also supported by Ottinger and Cohen (2012), who call for the incorporation of values into technoscientific practices and strategies for research and innovation, for instance by introducing engineering students to concepts of environmental justice and asking them to embed those concepts into their technical work.

A pedagogical strategy put forward by Goldman et al. (2014) that involves the learners in decision-making processes integrating the ethical dimensions of environmental challenges and engineering design choices is *socio-scientific issues* (SSI) (Applebaum et al., 2010; Tytler, 2012, cited in Goldman et al., 2014). This strategy includes socio-moral discourse, argumentation, debating, decision-making that requires evaluation of claims, distinguishing between concepts and context as well as science content knowledge. Another pedagogical approach put forward by [Seager et al. \(2012\)](#) is *sustainable engineering science* (SES). SES is an integrative approach to science, education, and technology that: “(1) draw upon an ethical awareness that extends beyond the usual bounds of professional ethics or responsible conduct of research to include *macroethics*, (2) adopt anticipatory and adaptive approaches to unintended consequences resulting from technological innovation that result in more *resilient* systems, and (3) cultivate *interactional expertise* to facilitate cross-disciplinary exchange” (Seager et al., 2012, p. 467).

Simsek (2011) reviewed 2002 6th, 7th, and 8th grade science and technology curricula and textbooks to find out to what extent and how environmental ethics and environmental aesthetics were mentioned. Simsek focused on the ethical and aesthetical elements of respect (of the right to life of every living thing), value (of living and non-living things, not only for the benefits of humans, but also in themselves), responsibility (for the things happening in students’ existing environment), participation (in actively addressing environmental problems), and compensation (for the harms to living and non-living things). He found that although most expressions mentioning environmental ethics in the textbooks emphasize responsibility and participation, there was a tendency to neglect respect, value, and compensation. This is

problematic, as students' sense of responsibility for environmental problems and their participation in addressing these problems depends on realising that they must respect and value nature and other living things' right to live. Simsek therefore recommends that both in curricula and textbooks, ethical and aesthetical elements should play a more prominent role, especially when it comes to respect, value, and compensation.

For policymakers

The recommendations for policymakers from the included literature focused mostly on the conditions to make the energy transition (more) just. We start with general recommendations and then move to specific recommendations in the EU context. Recommendations for policymakers also focused mostly on participatory or procedural justice; other considerations, such as social and distributive justice, also played an important role.

Fair participation of local communities (Feldman, 2011; Hilser et al., 2024; Lawrence & O'Faircheallaigh, 2022; Mahlanza et al., 2016; Samet, 2001; Stephens, 2024). The decision-making processes must include all the groups affected by environmental policies, and these groups must equally participate. Several steps are required to do so. First, policymakers must be proactive, typically by reaching out to affected groups to inform them about the environmental technologies that are being endorsed and respond to their concerns. Second, policymakers should adopt community-based and localized governance approaches that encourage a sense of agency, ownership, and deliberation. Importantly, indigenous people should be able to influence government and corporate decision-making, for instance by incorporating Indigenous landowners into the legislative framework governing mining operations and mine closure. Third, they should also prioritise feminist, antiracist perspectives to counterbalance current power and wealth imbalances and pay attention to who has power and privilege, who is being excluded or marginalized, what legacy processes and priorities are perpetuating discrepancies in power, and ultimately whether and how power is being concentrated or distributed.

Co-production of knowledge and co-design of technological innovation (Forsyth & McDermott, 2022; Khayat, 2023; Macdonald et al., 2021). Environmental and climate policies should focus more on the experiences of marginalized groups in the face of environmental impacts, typically by seeking ways to adopt forms of knowledge co-production to increase the participation of these groups in the planning and implementation processes. Technologies used to address environmental issues, including digital technologies used to gather data on environmental change, should be co-designed and co-developed with the involvement of the local and Indigenous people that will be affected by these technologies.

Social and distributive justice (Batel & Devine-Wright, 2017; Vaishnav, 2023). The socio-economic inequality between and within the groups affected by the energy transition should be addressed, typically in the areas where new energy infrastructure is built, for instance by supporting a sustainable decentralised local transition. Unless carefully managed, the energy transition can exacerbate socio-economic inequalities, typically by burdening those who do not benefit from new technologies but must pay for the cost of maintaining them. Regarding

transportation technologies, providing rebates for electric vehicle purchase tends to benefit the well-off, as tax credits usually benefit those with substantial tax burdens and large incomes. A fairer solution would be to offer the credits upfront at the point of purchase. Likewise, switching public transit to zero-emission alternative fuel vehicles would expand access to these technologies while reducing air pollution, which affects disproportionately the poor. Equitable access to mobility, including smart mobility, relies on the expansion of access to digital technologies such as the Internet and payment systems. As Vaishnav (2023, p. 520) highlights in a review of the literature on green technologies from an environmental justice perspective, the energy transition creates new interdependencies between sectors, which requires integrated design of policies and infrastructure in different sectors:

“No infrastructure or policy should be designed without considering the implications for sustainable, equitable access to energy services. For example, choices made to enhance equitable access to housing must not produce inequitable access to energy services. Architecture and building construction practices must seek to reduce operational energy use and cost. Electrification underpins green technologies in the building and transport sectors. Access to green technologies in electricity, building, and transport sectors can no longer be thought of separately: Each sector must catalyze green technology in others.”

Education and awareness raising (Gao & Zhou, 2022; Hartley et al., 2021). Education and awareness are important both for enabling and developing community-driven decision-making, and for encouraging the adoption of green technologies. On the one hand, environmental justice focused educational materials and online mapping tools that communicate demographic and environmental data to the public enable citizens to make informed decisions. On the other hand, outreach and public engagement campaigns to increase public understanding of the benefits of green technologies and the availability of public incentives and subsidies can encourage certain people and communities to adopt technologies such as solar panels.

The main ethical concerns discussed in the literature in the context of the European energy transition are the following:

Participatory and distributive justice (Arias et al., 2023). To ensure stakeholders have access to necessary data for decision-making and avoid greenwashing, transparent and reliable information on energy transition action plans is crucial. Lack of access to data challenges local communities and other stakeholders' participation in the decision-making process on energy transition strategies. Equitable access to renewable energy technologies implies promoting renewable energy in marginalised areas. This can be done by expanding the electricity grid to reach marginalised areas; by providing smaller, localized grids to generate power directly within the community; by promoting off-grid renewable energy solutions, such as solar home systems or mini-grids, in areas where extending the main grid is not practical; and by improving financial incentives and support to low-income communities to facilitate the purchase and installation of renewable energy technologies.

A sustainable energy transition (Arias et al., 2023). To be sustainable, the energy transition should not only provide a healthier environment but also promote economic growth and social well-being, for instance by creating jobs in the energy sector. It should also adhere to the principles of sustainable development and circularity, demonstrating environmental, social, and

economic benefits, and avoiding the underutilization of renewable resources. Policies should consider the Sustainable Development Goals (SDGs), especially in terms of food and energy security. These concerns highlight the need for a balanced approach that considers environmental, social, and economic dimensions to achieve a sustainable energy transition.

An improved life-cycle analysis (Hoffman, 2017). Life-cycle analysis (LCA) should not only include environmental matters and be too restricted geographically, but should also include effects on society and on distant localities. The collection of comprehensive life-cycle impact information which includes both environmental and socio-economic effects, for renewable energy systems and other products, should be a legal requirement. Such a comprehensive life-cycle approach should be used for both ranking and certifications systems, and be protected by legal greenwashing protection legislation and appropriate monitoring

Literature in China, Taiwan, Korea, and Japan

In addition to the systematic literature review, an expert review was conducted to cover literature in China, Taiwan, Korea, and Japan based on keywords covering the key topic areas (see table 10). We start with a comparison between the systematically reviewed literature above and the expert review, and then move to a discussion of each literature set from the expert review.

Table 10: Keywords and results for key topic areas in Chinese, Taiwan, Korean, and Japan literature

Keywords	Database	Hits
Environmental justice	Airiti Library (Taiwan)	927
	CiNii (Japan)	124
	CNKI (China)	2011
	KCI (Korea)	7806
Environmental ethics	Airiti Library (Taiwan)	1720
	CiNii (Japan)	1001
	CNKI (China)	3695
	KCI (Korea)	2936

Climate justice	Airiti Library (Taiwan)	94
	CiNii (Japan)	51
	CNKI (China)	258
	KCI (Korea)	580
Climate ethics	Airiti Library (Taiwan)	1
	CNKI (China)	140
	KCI (Korea)	200
Environmental justice and research integrity	KCI (Korea)	24
Environmental justice and research ethics	CNKI (China)	159
Environmental ethics and research ethics	CNKI (China)	1978
	KCI (Korea)	66
Environmental ethics and research integrity	CNKI (China)	3
	KCI (Korea)	43
Climate ethics and research integrity	Airiti Library (Taiwan)	3
Climate justice and research ethics	CNKI (China)	18

The first striking result is that, just as in the systematically reviewed literature, environmental justice and environmental ethics display substantially more hits than climate justice and climate ethics. While environmental justice clearly dominates the Korean literature, environmental ethics is dominant in the Taiwanese, Japanese, and Chinese literatures. Climate justice is more important than climate ethics across all literatures, with only one mention of climate ethics in the Taiwanese literature, and no single mention of it in the Japanese literature.

A second similar finding is that there is an important gap between the literature on environmental ethics/justice and climate ethics/justice and the one on research ethics and research integrity. The most significant overlap was found in the Chinese literature between environmental ethics and research ethics (1978 hits), and environmental justice and research

ethics (159 hits), but the results were of very low relevance, indicating that the terms "research ethics" and "research integrity" were not effective search words. The same applies to the Taiwanese (very limited overlap) and Japanese literatures (no overlap). This also applies to the Korean literature, where research ethics and integrity discourses are still largely dominated by topics such as research environments, education on research integrity, research misconduct, intellectual property, and other general aspects of research ethics. However, interestingly, research ethics and integrity could be connected to environmental ethics in Korean literature through risk management, and to climate ethics through the notion of "responsibility," which covered individual responsibility, science and technology, and environmental, social and governance management. This suggests that risk and responsibility could represent potentially relevant cross-cutting concepts in the Korean literature, but these findings should be reinforced by a more systematic review of the literature.

Turning to the discussion of each literature set, the content analysis on Chinese academic literature was conducted on 29th July 2024 on the China National Knowledge Infrastructure (CNKI) database. The primary keywords used were "climate ethics" (气候伦理), "environmental ethics" (环境伦理), "climate justice" (气候正义), "environmental justice" (环境正义), and combinations of the above keywords with the secondary keywords of "research ethics" (研究伦理) and "research integrity" (科研诚信).

In China, the term "environmental ethics" (环境伦理) has also been translated into "ecological ethics" (生态伦理), with the latter being more widely used at the beginning of environmental ethics studies. The environmental ethics and environmental justice studies appeared in the early 1990s and gained an increasing popularity since the 2000s. The primary objective in initial studies was to introduce and translate Western concepts of environmental ethics and environmental justice to make them fit into the national context. Chinese scholars have gradually become self-aware of the conceptual limits of this approach and started reevaluating their own philosophical traditions. Notable examples include Confucianism, Taoism, Lao-tzu, Buddhism, Marxist ecology, and Xi Jinping's Thought on Ecological Civilization. Although the growth of literature peaked before the 2010s, the recent environmental policies in China, since President Xi Jinping expressed his Thought on Ecological Civilization (生态文明思想) in 2018, continue to push the research development on environmental ethics and justice. Despite this, the concepts of "environmental ethics" and "environmental justice" are being used mainly within academic circles, and rarely in the political and social realms.

The content analysis on Korean academic literature was conducted on September 6th and 23rd 2024, using the Korea Citation Index (KCI) database. The keywords used were "climate ethics" (기후윤리), "environmental ethics" (환경윤리), "climate justice" (기후정의), "environmental justice" (환경정의), and combinations of the above keywords with "research ethics" (연구윤리) and "research integrity" (연구진실성).

While environmental ethics and environmental justice first appeared in the early 1990s, climate ethics only started to emerge in the late 2000s in the Korean literature. The concepts and issues

that highlight the particularity of Korean discourse on environmental and climate ethics include ecological/climate/environmental crisis, Christianity, life, ecology, education, activism, and inequality. Asian approaches to environmental ethics include Confucianism, Taoism, Lao-tzu, Buddhism, and Shamanism; European approaches based on pragmatism, Kant, Hegel, or Heidegger also appear in the literature. One notable feature is the significant role of religion, particularly Christianity, in producing academic debates on environmental ethics by addressing issues such as bioethics and ethical responsibility. In contrast, discourses on environmental and climate justice appear to engage more with specific local policies, laws, education, and justice movements driven by interests on democracy and inequality.

Turning to the content analysis on Japanese academic literature, the search was conducted between August 1st and September 30th 2024, using the databases of Google Scholar, J-STAGE, and CiNii. The keywords and phrases used include “climate ethics” (気候倫理), “environmental ethics” (環境倫理), “climate justice” (気候正義), “environmental justice” (環境正義), and “eco-philosophy” (エコ・フィロソフィ), and combinations of the above keywords and phrases with “research ethics” (研究倫理) and “research integrity” (研究インテグリティ).

Japanese literature that addresses environmental ethics or environmental justice presents arguments similar to those found in English-language scholarship. In contrast, eco-philosophy in Japan has been discussed in relation to Shinto, Buddhism, Hinduism, and Chinese thought. The development of eco-philosophy has been led primarily by Tokyo University and Ibaraki University within the framework of the Integrated Research System for Sustainability Science, a research network established by The University of Tokyo to serve as a global platform for research and education in sustainability science.

One of the most influential works on climate justice published in Japan is *Climate Justice: Normative Theories for Confronting Global Warming* (気候正義：地球温暖化に立ち向かう規範理論) by Makoto Usami (宇佐美誠), in 2019. The author’s expertise spans legal, political, and economic philosophy, and the issues are examined from various yet interconnected perspectives. Similarly to the systematically reviewed literature on climate justice, this edited volume puts a strong emphasis on the just distribution of the burdens associated with mitigation efforts aimed at slowing down climate change. Similarly, the question of cost distribution arises in relation to adaptation measures that seek to minimize the harmful effects of climate change. Another similarity is that the volume features the seminal work of Henry Shue on climate justice, with a complete translation of his 1993 paper on subsistence and luxury emissions (Shue 1993). Finally, the results also demonstrate very low relevance in terms of research ethics and integrity, with almost no hits that connect to environmental or climate topics (only 2 hits on Google Scholar with “environmental ethics” and “research ethics” in the title).

Finally, the content analysis on Taiwanese academic literature was conducted on September 23rd 2024, using the Airiti Library database. The keywords used were “climate ethics” (氣候倫理), “environmental ethics” (環境倫理), “climate justice” (氣候正義), “environmental justice” (環境正義), and combinations of the above keywords with “research ethics” (研究倫理) and “research integrity” (科研誠信).

Discussions of environmental ethics and environmental justice began to emerge in the 1990s, and have gradually increased since then, with a peak of publications on environmental ethics in

2014. There are a certain number of papers that discuss environmental ethics by positioning Chinese philosophy (Taoist and Confucian) and Buddhist thought as alternatives to Western modernity. Importantly, since the 2000s, there has been an increase in social, political, and philosophical considerations of Taiwanese aboriginal peoples regarding topics such as “environmental justice,” “environmental rights,” and “environmental philosophy”. For example, some attempt to position and interpret aboriginal environmental views as an alternative to Western modernity, and others discuss aboriginal environmental rights.

Conclusion

A gap between environmental & climate ethics and research ethics & integrity

To clarify the implications of ethical and justice perspectives pertaining to the environment, and research ethics and integrity perspectives, we limited our scoping review to studies focused upon the environmental implications for research, innovation and technology development. While we anticipated that this would exclude much scientific literature on these perspectives, we did not anticipate the extent to which literature on research ethics and integrity would be excluded. This is especially surprising given the relative size of the wider literature on research ethics and research integrity. To give an illustration, a search in Scopus using our search string conducted on 7th February 2025 finds 744 documents. However, if we modify this search string to remove the requirement to mention either 'climate' or 'environment,' we find 3,121 documents. While a full screening of these databases would be necessary to precisely indicate the magnitude of literature we excluded by introducing this requirement, this illustration indicates that the vast majority of literature in research ethics and integrity does not explicitly mention environmental impacts. This neglect of the environmental and climate dimensions of research and innovation by research ethics and integrity communities was confirmed by the scoping review results highlighted above and by the findings in D1.3.

Aside from the small set of studies utilising the RRI framework, we did not find concepts of research ethics or research integrity applied to contexts of environmental impact or concern. We found that research ethics and integrity literatures have little to say about ethically significant impacts of research practices upon the environment. Many publications in business ethics, bioethics, and medical ethics that were reviewed had little or no connection to environmental or climate justice/ethics, and were therefore discarded in the first two phases (abstract and title screening and full text screening) based on the inclusion/exclusion criteria. This indicates that the literature on research ethics and integrity included in this review does not engage meaningfully with the environmental impacts of research, or the dimensions of ethics and justice which these may raise. Turning to the practice of research ethics and research integrity communities in the assessment of scientific projects, this research gap seems to imply a shortfall in the expertise necessary to consider the ethical dimensions of research and innovation pertaining to the environment. In response to this, capacity building efforts seem necessary to enable research ethics and integrity assessors to assess these ethical dimensions of research and innovation. At the same time, the reviewed publications on environmental justice/ethics also had very little to say about standards of research ethics, with the notable exception of literature on geoengineering. The literature on distributive justice, cosmopolitan justice, intergenerational justice, and so on, is largely disconnected from the literature on research ethics and research integrity. This confirms the need to develop research ethics guidelines and framework on the environmental aspects of research activities as well as training material reflecting these guidelines for students and researchers.

Fragmentation in climate ethics and environmental ethics

Another surprising finding was the degree of fragmentation that seems to exist in understandings of environmental ethics and environmental justice and climate ethics and climate justice. Contrary to our initial expectations, seminal philosophical contributions on climate ethics were not widely cited in the literature surveyed, despite their significant impacts on wider literature on climate policy and justice. For instance, Henry Shue's article 'Subsistence emissions and luxury emissions', widely considered to be a foundational piece of scholarship on climate justice, was cited in merely 2 studies included in our review, despite having 403 citations in the database Scopus alone (Shue, 1993). As noted above, this indicates that philosophical conceptions of climate justice have little overlap with discussions of climate justice applied to research, innovation and technology. A less restricted review, focused purely on the use of concepts, is therefore likely to present a very different picture of influential and cross-cutting concepts.

In contrast, the prominence of Schlosberg's (2007) philosophical conception of environmental justice across the literature surveyed indicates that literature on this topic is less fragmentary, revealing a greater degree of shared understanding. Nonetheless, even this relative finding should be viewed in the context of a larger fragmentation of understandings found across the literature. While Schlosberg's view is cited in 15 studies reviewed here, a much larger set of literature did not refer to this or any other shared understanding of environmental justice. This again confirms our finding that the literature surveyed reveals considerable conceptual fragmentation, and work that seems to run parallel to similar research being done by scholars in different sub-fields or disciplines. A clear illustration is the topic of energy justice. As noted already, this literature most often cited the view of Schlosberg when defining itself, which seems to reveal a degree of unacknowledged conceptual rebranding. The distinctive contribution of energy justice seemed to be the potential distributive, procedural, and restorative injustices raised by the energy transition, with the key topics of fair access to clean energy and the fight against energy poverty, the fair participation in the design and application of energy technologies, and the reparation of harms caused by the energy transition. Some scholars of energy justice, such as McCauley and Heffron (2018, p. 1), claim that energy justice might unite work on climate and environmental justice in providing "a more comprehensive framework for analysing and ultimately promoting fairness and equity throughout the transition away from fossil fuels". However, these seem to be applications of concepts of environmental justice (c.f. Schlosberg, 2007), rather than new concepts in their own right.

Over-represented topics and limitations

Among the environmental topics identified, the literature also reveals an over-representation of studies focused upon climate change, at the expense of other environmental issues. Most notable here may be research on biodiversity conservation, which is often compared in importance and urgency with climate change (e.g., IPBES, 2019; Steffen et al., 2018). Given the

European Commission's commitments to the protection of biodiversity, this may signal a need for increased research funding on this topic.

Another seemingly over-represented topic was research on the ethics and governance of geoengineering, which was the second most discussed technology area in our review (after energy technologies). This is also striking because many of the technologies that belong to this discussion are still the subjects of basic research or in early stages of technological development. The prominence of this literature, and its engagement with the responsible research and innovation framework may reflect efforts by this research community to establish anticipatory governance of research prior to any physical experimentation, due to the seriousness of concerns with ungoverned research.

A number of further limitations of the review became evident. First, the choice to limit included literature to peer reviewed studies thereby excluded policy documents and 'grey' literature which may have had more direct implications for policymakers or educators. As a result, the findings presented above on policy or educational recommendations must be viewed in the light of this limitation. This likely also explains the lack of literature providing more tangible recommendations for innovation and technology development.

A second limitation is that our search string only looked at the key topic areas in combination with technology and innovation, and not with research: as research is always the focus of research ethics and research integrity but is implicit in technology and innovation, forms of research which are not technology or innovation focused were not systematically included in the review. As explained above, this choice was made to avoid ending up with an unmanageable number of publications to review: to give an illustration, a search in Scopus using our search string conducted on 25th February 2025 finds 749 documents; adding "research" to "technology" and "innovation" as keywords brings the number of hits to 2,555 documents. However, the inclusion of research ethics and research integrity in the search string guaranteed that the literature referring explicitly to these key topic areas was included.

A third limitation is that, even with research ethics and research integrity integrated into our search string, our review did not include publications focused on the environmental impact of some technologies and innovations. One reason for this is that these publications do not engage with the environmental ethics or justice and or the climate ethics or justice concepts, and are therefore out of the scope of our review; another reason is that they do not necessarily explicitly engage with research ethics or research integrity. The recent literature on the environmental impact of AI (e.g., Ahmad et al 2021; van Wynsberghe 2021; Ahmed Alloghani 2024; Bolte and van Wynsberghe 2024) or of high-energy accelerators (e.g., Bloom and Boisvert, 2024; Breidenbach et al., 2023; Roser, 2022; Sustainable HECAP+ Initiative, 2023) are good illustrations of this: these publications cover the environmental impact of relevant domains of technological innovation but were not included because of their lack of engagement with the key topic areas on which this review focuses. These emerging literatures underscore the growing recognition of the environmental implications of AI and high-energy accelerators and highlight various strategies and recommendations to mitigate these effects, fostering a more sustainable approach to cutting-edge scientific research.

A fourth limitation of this review was the inclusion of literature on indigenous perspectives on ethics and justice, as these relate to research, innovation and technology development.

Although we modified an existing search string that was used by the IPBES to find literature on indigenous and local knowledge holders in the context of biodiversity conservation, little of the literature we collected with this modified search string qualified under our inclusion criteria. Literature on research ethics on indigenous lands and with indigenous peoples as participants (e.g., Holmberg et al., 2023; O'Brien et al., 2024) was not identified by our searches, despite the relevance of this for the environmental ethical and justice-related dimensions of research. There seem to be three reasons for this. First, as noted, some of this literature is not peer reviewed, and was thus inadmissible under our inclusion criteria. Second, this literature may not explicitly mention environmental or climate-related dimensions, which may be implicit already given the context, such as in research on Saami territory in the Arctic. Third, even if some publications do mention environmental concerns, they do not necessarily frame them as environmental ethics/justice or climate ethics/justice concern, and were therefore not tracked by our search query, which only included results mentioning ethics or justice within three words before or after the occurrence of “climate” or “environment”. Broadening the scope of the review beyond ethical or justice-related concerns would have led to too many results.

Finally, as noted above, the lead author affiliations identified above reflect the structural dominance of the Global North in academia (Schöpf, 2020). The largest author affiliations were from the US (67 studies, 43%), the EU (28 studies, 18%) and the UK (23 studies, 15%). Additionally, no European lead author affiliations came from outside the EU (except the UK and Switzerland), which may reflect the intra-European inequalities between the EU and its periphery. This could be in part due to the language specifications of the search, for example no search string included Arabic and hence there is no representation of North African or West Asian research institutes. Central and Southern Africa is also underrepresented, with only three articles (1 from Nigeria and 2 from South Africa). Despite the inclusion of Spanish in the search string, no lead author affiliations came from Latin America. This underrepresentation of the global periphery in our research findings reflects what Schöpf (2020) calls “academic dependency”, wherein countries in the global periphery depend on finance and technology from dominant nations to secure academic legitimacy. A recommendation would therefore be for research funding to support collaborations with under-represented regions.

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