

## **Exploring the empirical evidence on biocultural diversity: a systematic map protocol for papers written in English and Spanish**

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## **ABSTRACT**

### *Background*

The term biocultural diversity (BCD) refers to the diversity of life in all its manifestations, including biological, cultural, and linguistic diversity, and the interactions among them within a socio-ecological system. As human societies interact with the natural world in unique ways, BCD recognizes the link between biodiversity and their knowledge, beliefs, practices, and values. However, the challenge now is on how to improve human livelihoods without harming nature in a context where global change is threatening both ecosystems and human well-being. Biocultural approaches aim to merge social sciences and natural sciences in order to bridge the divide between disciplines and try to solve the sustainability issues we are facing. Nevertheless, to achieve that, the BCD concept still requires some clarification, indicators for its quantification, and more integration with the social-ecological systems (SES) science.

We present a protocol to systematically map BCD and explore how this concept has been empirically addressed in scientific research articles written in English and/or Spanish. This systematic map aims to highlight research gaps, create a spatial database of evidence, point out actions that have been taken through biocultural approaches and provide evidence to inform future decision-making processes.

### *Methods*

We will search a suite of bibliographic databases for relevant research literature. We will screen identified and retrieved articles at two stages (1. Title/abstract and 2. Full-text), according to a predefined set of inclusion/exclusion criteria. The consistency of these criteria will be checked in order to ensure that they can be operationalised.

We will extract detailed information on the BCD concept and the study and practical application of this concept as a tool for addressing environmental and sustainability issues in social-ecological systems, as well as descriptive information about the articles. We will visualise this database on an Evidence Atlas, identifying knowledge gaps and clusters by using descriptive analysis.

## **KEYWORDS**

Evidence synthesis; social-ecological systems (SES); biocultural approaches; biocultural diversity components; conservation.

## 1.- BACKGROUND

Biocultural diversity (BCD) can be defined as the ‘diversity of life in all its manifestations —biological, cultural, and linguistic— which are interrelated within a complex socio-ecological adaptive system’ (Maffi 2005). It includes biological diversity at all its levels, from genes to populations to species to ecosystems; and cultural diversity in all its manifestations (including linguistic diversity), ranging from individual ideas to entire cultures; and, more importantly, the interactions among all of these. In essence, BCD is the fundamental expression of the variety upon which all life is founded (Loh & Harmon 2005). This concept recognizes that human societies have developed unique ways of interacting with and utilizing the natural world, resulting in a diversity of knowledge, beliefs, practices, and values that are intimately linked to the biodiversity of their local environment (Maffi 2005). Different cultures and peoples perceive and appreciate biodiversity in different ways because of their distinct heritage and experience (Cocks 2006).

Nowadays, developing pathways that allow for improvement of human livelihoods without degrading nature and while preserving ecosystem services is proving to be one of the biggest and most urgent challenges for humanity (Díaz et al. 2018). At the same time, ecosystems and thus human well-being, are currently threatened by environmental and social changes grouped under the term "Global Change" (e.g. effects of climate change, land-use change, migratory flows) (Millennium Ecosystems Assessment 2005). Biocultural approaches, by recognizing the inextricable linkages between human societies, their cultural dimension, and the natural environment in which they exist, strive to integrate biophysical, socio-cultural, and other kinds of data and methods. Thus, they bridge the divide between disciplines in the social sciences and those in the natural sciences to try to solve these kinds of problems. Furthermore, BCD is an integral part of sustainability science research because it embraces both the biological diversity of ecosystems and the cultural diversity of human societies (Maffi 2007).

However, despite the increased recognition and research on BCD, a major clarification of the BCD concept, indicators for its quantification and, its integration with the science on social-ecological systems (SES) are so far still missing. Current research on BCD is facing a dilemma from theoretical approaches to practical implementation. On the one hand, studies at bigger different scales need reliable biological and cultural data sets to be conducted, but the funding for BCD research and conservation actions is scarce. On the other hand, this research and actions require the integration and application of interdisciplinary expertise and the collaboration between many different actors (Zhao et al. 2022).

The most recent systematic reviews on BCD focused on biocultural approaches to sustainability (Hanspach et al. 2020; Díaz-Reviriego et al., under review), traditional ecological knowledge (Sharifian et al. 2022; Burke et al. 2023) and BCD enhancement pathways (Zhao et al. 2022). Nevertheless, as far as we are concerned, there is not a global systematic mapping on BCD considering at the same time literature written in English and Spanish. The decision to conduct our search in both English and Spanish stems from three main reasons. Firstly, English is widely recognized as the dominant language in scientific research, and many relevant studies and publications are available in this

language. Secondly, Spanish is the preferred language for scientific publications in relevant hotspot areas for BCD such as Latin America. Thirdly, English and Spanish are the languages in which the authors conducting this study have extensive fluency and experience. By including literature in these two languages, we aim to access a wider range of scholarly articles and ensure a more inclusive representation of BCD research, encompassing diverse perspectives and experiences. We intended to minimize language bias and maximize the breadth of knowledge available on BCD, ultimately providing a more holistic understanding of the concept and its empirical exploration. Nevertheless, it is important to note that our search may not fully represent the entirety of BCD research, as it does not encompass other languages. We acknowledge this limitation and recognize that there may be valuable contributions in other languages that are not captured in our search; yet, we firmly believe that this systematic mapping process is highly relevant and valuable in providing insightful contributions.

This paper presents a protocol to systematically map BCD and explore how this concept has been empirically addressed in scientific research articles written in English and/or Spanish. By doing so, we will: (1) highlight research gaps on this topic, (2) create a spatial database of evidence on BCD, (3) point out actions that have been or are being taken through the BCD lens to address environmental and sustainability issues in social-ecological systems and, (4) provide evidence to inform future decision-making processes for BCD conservation and restoration. The systematic evidence map will be created by extracting and collating data from relevant studies found in different databases, with a basic descriptive analysis of trends and patterns after which a full systematic review can be conducted in the future.

This protocol is organised into the following sections: objectives of the systematic map (Section 2), stakeholder engagement (Section 3.1), search strategy and assembling a library of academic literature (Section 3.2 outlining sources searched, search string used and methodological choices made for compiling literature), screening process and eligibility criteria (Section 3.3), data extraction and coding (Section 3.4 detailing how the search results were analysed in terms of a specific coding scheme created), and study mapping and presentation of results (Section 3.5).

## **2.- OBJECTIVE OF THE SYSTEMATIC MAP**

The primary research question of this systematic map is ‘What empirical evidence written in English and/or Spanish exists on biocultural diversity?’. By trying to answer this question, our systematic mapping process aims to gather information about how the concept of BCD has been studied and applied to address environmental and sustainability issues in social-ecological systems. The evidence base will be categorised using a data-coding framework (Section 3.3) designed to explore the following secondary questions:

- 1.1) Where has the concept of biocultural diversity been studied, addressed and applied for facing environmental and sustainability issues?
- 1.2) Which types of social-ecological systems have been studied?
- 1.3) Are these study areas protected? Which protection figures have been used to preserve biocultural diversity?

- 2) What components of biocultural diversity have been empirically studied?
  - 3.1) Which actions for biocultural diversity conservation have been taken in scientific empirical studies?
  - 3.2) Who has been carrying out these actions?
  - 4.1) Which are the future actions for biocultural diversity conservation suggested by researchers in empirical scientific papers?
  - 4.2) Who will be carrying out these actions?

### **3.- METHODS**

This systematic map protocol has been developed in accordance with the Collaboration for Environmental Evidence Guidelines and Standards for Evidence Synthesis (2022) and the ‘RepOrting standards for Systematic Evidence Syntheses’ (ROSES) for systematic map protocols (Haddaway et al. 2018). Furthermore, Lawrence et al. (2021) was taken as a recent systematic map protocol example published in *Environmental Evidence*, a journal that publishes evidence syntheses relevant to environmental management and that is managed by the Collaboration for Environmental Evidence (CEE). Another paper used as an example of systematic mapping methodology was Goodwin et al. (2023).

#### **3.1 Stakeholder engagement**

The topic of this study was formulated by CQS in her Marie Skłodowska–Curie Project ‘Social-ecological pathways and gender perspectives for future conservation of biocultural mountain agro-ecosystems’ (funded by the EU under grant number 101031168). The research team, consisting of members with diverse interests and expertise in the fields of environmental sciences and ecology, keeps in frequent informal communication with stakeholder groups (i.e. other scientists, people living in rural areas, farmers and elders, among others) on a daily basis. Given the scope of this part of the project, it was not deemed necessary to formally consult with separate stakeholder groups during the development of the project objectives and methods.

#### **3.2 Search strategy and assembling a library of academic literature**

This strategy details the steps that we will take to ensure that a comprehensive and unbiased search and academic literature compilation is conducted on the most relevant available knowledge.

The first step of our literature compilation process will be to contact Hanspach et al. (2020), Burke et al. (2023) and Díaz-Reviriego et al. (under review), researchers who had previously conducted systematic reviews on BCD. Their reviews focused on papers written in English from 1990 to 2018 (Hanspach et al. 2020) and papers written in Spanish from 1990 to 2018 (Burke et al. 2023) and from 1990 to 2021 (Díaz-Reviriego et al., under review). We will ask these researchers to share with us their database of articles in order to search for the same papers they have previously selected as relevant to study the

BCD concept as a tool for addressing environmental and sustainability issues in social-ecological systems.

On the one hand, Hanspach et al. (2020) queried the Scopus database with the search strings '*biocultural*' OR '*bio-cultural*' in Title, Keywords and Abstract for publications between 1990 and 2018. This query returned 1,359 publications and they finally analysed 178 papers in-depth. Other databases than Scopus were not considered, acknowledging the limitations of this approach, because they were mostly interested in gathering the scholarly literature on the topic that had been published in international journals in English.

On the other hand, Burke et al. (2023) and Díaz-Reviriego et al. (under review) searched for papers written in Spanish in four different databases: 'Scielo' (<https://scielo.org>), 'Redib' ([www.redib.org](http://www.redib.org)), 'Redalyc' ([www.redalyc.org](http://www.redalyc.org)) and 'Dialnet' (<https://dialnet.unirioja.es>). The search string used in Title, Keywords and Abstract was '*biocultural*' OR '*bioculturales*' for papers published between 1990 and 2018 (Burke et al. 2023) and from 1990 to 2021 (Díaz-Reviriego et al., under review). The most recent and updated search (Díaz-Reviriego et al., under review) yielded 932 publications, out of which 143 were thoroughly analyzed.

These searches were limited to studies published from 1990 to 2021. This decision was made taking into account that 'biocultural diversity' is quite a recent concept that started to be mentioned and addressed in the 90s and that has been almost exponentially growing since then.

Thus, in order to complement the previous information gathered by Hanspach et al. (2020) and to have a set of literature comparable to Díaz-Reviriego et al. (under review), we will search Scopus database for English papers between 2019 and 2021. For the sake of future comparisons between search results, we used the same search string as Hanspach et al. (2020): '*biocultural*' OR '*bio-cultural*' in Title, Keywords and Abstract. Advanced search options will be utilised using the Boolean operator 'OR' and Scopus filters to select papers in English published between 2019 and 2021.

Studies obtained from the above mentioned bibliographic databases will be combined into the Zotero reference management software. This will allow us to assembly our library of academic literature and full texts in PDF format. For the papers that could not be found using Zotero or on the Internet, we will contact the authors by ResearchGate or by e-mail and politely ask them to send us a copy in PDF format.

### **3.3 Screening process and eligibility criteria**

#### Screening process

Once the search is complete and the library assembled, all potential papers found from all sources will be collated into a single Excel file for further screening. For all these articles, a two-step screening process will be conducted. The first step will involve screening each study title and abstract text simultaneously (first screening process) for relevance using the eligibility criteria (listed below). Studies that meet the inclusion criteria will then pass the first stage of screening and be reviewed at the full text stage (secondary screening process). If it could be identified that a study explicitly does not meet these criteria, it will

be excluded, and the reason for its exclusion will be recorded. Additionally, any studies with uncertainty about the relevance based on the title and abstract (i.e. if it is not clear if it should or should not be included) will pass to the next round of screening and be reviewed at the full text stage.

The second stage of screening will entail a more robust review of all studies at full-text level. Papers could be excluded at this stage if by reading the full text more information came to light that they did not actively meet the inclusion criteria. The reasons for exclusion will be recorded. In this stage, if doubt remained on the eligibility of the study based, the study will be marked as '*NOT CLEAR*' and its eligibility discussed with the other reviewers. Finally, all studies meeting our inclusion criteria will be separated on a different Excel file to start the data extraction and coding process.

To guide reviewers' choices of including or excluding an article through all the screening process, we have created a document that includes a set of criteria and guidelines for screening (*Appendix S1* in supplementary material). Furthermore, to assess the repeatability of the screening process we will compare the choices made by different reviewers. To do so, during each screening stage a subset of 20 articles will be assessed by three reviewers and their agreement on inclusion/exclusion evaluated to ensure the reliability of the screening process (*Appendix S2* in supplementary material). In addition, periodic meetings will be scheduled to discuss doubts or difficulties during the screening process. This will be repeated at each screening level (first and secondary screening).

#### Eligibility criteria

To pass the first screening stage articles must fulfill the following inclusion criteria:

- Papers related to sustainability and environmental issues.
- Papers related to natural resource management, conservation or restoration.

The reasons for exclusion at first screening level will be:

- Papers focused on Archeology, Human Evolutionary Biology, Psychiatry, Physical and Biological Anthropology and Medical Disciplines.
- Publications written in other languages different from English and Spanish.
- Books, book chapters and scientific documents other than articles.

For the secondary screening process that involves full-text reading the inclusion criteria will be:

- Empirical papers.
- Papers in which the main text explicitly mentions '*biocultural diversity*', '*biological and cultural diversity*', '*diversidad biocultural*' or '*diversidad biológica y cultural*'.
- Papers with a substantial amount of text dedicated to biocultural diversity or biocultural approaches.
- Papers with an in-depth engagement with biocultural approaches to sustainability.

Exclusion criteria in this secondary screening will be:

- Papers other than empirical: conceptual, discussion or review papers. Furthermore, books, book chapters and scientific documents other from empirical

papers that we missed to exclude on the first screening process will be excluded here.

- Papers not explicitly mentioning ‘*biocultural diversity*’, ‘*biological and cultural diversity*’, ‘*diversidad biocultural*’ or ‘*diversidad biológica y cultural*’ in the main text.
- Papers in which the content does not engage with biocultural approaches.
- Papers that only use ‘*biocultural*’ as a buzz word (not a substantial amount of text dedicated to biocultural diversity or biocultural approaches).

A full list of studies excluded at full text stage will be provided in the final systematic map publication as an additional file including reasons for exclusion (example file in *Appendix S2*). Studies that cannot be located or accessed will also be reported.

On the other hand, to clarify some key concepts mentioned in the previous eligibility criteria, *Table 1* lists the definitions of the terms used in this protocol document that are relevant for the screening process.

*Table 1. Definitions of key terminology to be used in the screening process.*

| <b>Key terminology</b>  | <b>Definition</b>  |
|---|--|
| <b>Sustainability</b>   | Meeting the needs of current generations without compromising the needs of future generations, while ensuring a balance between economic growth, environmental respect, and social well-being. (World Commission on Environment and Development 1987).   |
| <b>Environmental issues</b>                                       | Harmful effects of human activities on the environment. Ex. air, water or soil pollution; deforestation; climate change; biodiversity loss; depletion of natural resources, etc. (own definition).   |
| <b>Natural resources management, conservation and restoration</b> | Process aimed at managing the use, development, conservation and restoration of natural resources in a sustainable manner. It involves the planning, implementation, and monitoring of activities aimed at optimizing the use of natural resources while ensuring their long-term availability and preserving their ecological integrity (own definition).   |
| <b>Empirical paper</b>  | Research paper that presents original research based on empirical evidence, that is primary data that is obtained from direct observation or experimentation at a specific study area <sup>1</sup> , rather than from theoretical or hypothetical reasoning (own definition).  |
| <b>Biocultural diversity (BCD)</b>                                | Diversity of life in all its manifestations —biological, cultural, and linguistic— which are interrelated within a complex socio-ecological adaptive system (Maffi 2005).  |
| <b>Biocultural approaches</b>                                     | Methods that recognize the interdependence between biological and cultural diversity to address sustainability, environmental and social issues by adopting a systems perspective on human–environment interactions, implementing inter- and transdisciplinarity and committing to provide solutions. Biocultural approaches can be “seen” through 7 different biocultural lenses (Hanspach et al. 2020): biocultural diversity concept; conservation; landscapes and natural resources management; history and heritage; knowledge and memory; ethics, rights and sovereignty; and, restoration, transformation and design. |

(1) Note: Studies using secondary data, not presenting original data, only doing a compilation of previous data or only describing a case study (not extracting data) will not be considered as empirical papers in this systematic mapping process.



### 3.4 Data extraction and coding

During the meta-data extraction process, we will be using Google Drive Sheets (<https://docs.google.com/spreadsheets/create>) to provide a platform for collaborative extraction of data from the selected studies. Two reviewers (IOU and ASL) will code data. Metadata will be extracted from each relevant study that satisfies the inclusion criteria using a standardised coding and data extraction template (see *Appendix S2*). The authors will review and refine this coding and data-extraction template by conducting a pilot study with 20 papers. After the pilot test has been run, necessary adjustments will be made to the framing of the template. Testing will be repeated with the adjusted framework until no further changes are needed.

The following main categories of data will be extracted (*Appendix S2* for more detail): paper ID, general information, study area, biocultural diversity components, current efforts and future efforts. The specific categories in each main category are presented in *Table 2*. New categories and codes could be added inductively during the data extraction and coding process.

*Table 2. List of main categories, categories and codes for meta-data extraction and coding (see Appendix S2 for a more detailed list of variables and coding guidelines).*

| Main Category              | Category                 | Description   | Data type        | Meta-data extraction or coding |
|----------------------------|--------------------------|---|------------------|--------------------------------|
| <b>Paper ID</b>            | Final Code               | Final code for identifying each paper. English papers (1990-2018) will be coded as Final_E_Number. Spanish papers (1990-2019) will be coded as Final_S_Number. English papers (2019-2021) will be coded as Final_EN_Number. | Nominal          | Coding                         |
|                            | Paper abbreviation       | Paper's short name (First author's last name and publication year). Ex: Hanspach et al. 2020.   | Nominal          | Coding                         |
| <b>General information</b> | Author                   | List of all the authors.  | Nominal          | Meta-data extraction           |
|                            | Year                     | Publication Year.   | Numeric discrete | Meta-data extraction           |
|                            | Title                    | Title of the paper.   | Nominal          | Meta-data extraction           |
|                            | Journal                  | Journal in which the paper was published.   | Numerical        | Meta-data extraction           |
|                            | Language                 | Language in which the paper has been written. English or Spanish.   | Categorical      | Coding                         |
|                            | DOI                      | doi or link to the paper online.  | Link             | Meta-data extraction           |
|                            | Country leading research | First author's country of affiliation.  | Categorical      | Meta-data extraction           |
| <b>Study area</b>          | N study areas            | Number of areas studied in the paper.   | Numerical        | Meta-data extraction           |
|                            | N countries              | Number of countries represented by the areas studied in the paper.  | Numerical        | Meta-data extraction           |
|                            | Study area               | Name of the study area.   | Nominal          | Meta-data extraction           |

|   |                     |  |  |                      |
|---|---------------------|--|--|----------------------|
|   | Country             | Country or countries in which the study area is located.   | Nominal                                    | Meta-data extraction |
|   | Latitude            | Latitude coordinates of the study area.  | Numerical continuous                       | Meta-data extraction |
|   | Longitude           | Longitude coordinates of the study area.   | Numerical continuous                       | Meta-data extraction |
|   | Scale               | Scale at which the study was conducted: local (few communities), landscape (bigger than local but smaller than regional), regional (bigger areas, province level), national, supranational, continental, or global.  | Categorical                                | Coding               |
|   | Type of system      | Systems studied: terrestrial natural systems, freshwater systems, marine systems, agroecosystems, rural systems, urban systems or complex systems.   | Categorical (Binary 0/1 for each category) | Coding               |
|   | Protection          | Is the study area protected? Yes/No.   | Dummy                                      | Coding               |
|   | Protection category | Protection category of the study area if it is protected: Strict Nature Reserve, National Park Natural Monument, Habitat/Species Management Area, Protected area with sustainable use of resources, UNESCO World Heritage, Biosphere Reserve, Natura 2000, Natural Reserve, Other national protection figures, Other regional protection figures, Indigenous territory/conserved areas, Local community-established reserves/protected areas, Ethnobotanical Park/Garden or Other.   | Categorical (Binary 0/1 for each category) | Coding               |
| <b>Biocultural diversity components (1<sup>st</sup> classification based on Elands et al. 2019)</b> | Materialized        | Components of materialized BCD studied in the paper. Materialized BCD is primarily concerned with the identification and quantification of the tangible biophysical expressions of BCD. Genetic diversity, Plants, Animals, Other living-beings, Ecosystems, Landscapes, Products / Tools, Infrastructure or Other.  | Categorical (Binary 0/1 for each category) | Coding               |
|   | Lived               | Components of Lived BCD studied in the paper. Lived BCD relates to the day-to-day practices of people experiencing places, encompassing both biological and cultural features. Lived BCD is concerned with the perceived and experienced qualities. These are mediated by our senses and minds, and concern complex systems of values, norms, traditions, knowledge and sensory perceptions. Praxis (practices, uses or other), Language (language diversity, words/vernacular names, language for knowledge transmission or other), Corpus (knowledge, knowledge transmission or other) and Kosmos (cosmivision-worldview/beliefs-taboo/religion, values, identity/HNC /sense of place-community or other). | Categorical (Binary 0/1 for each category) | Coding               |
|   | Stewardship         | Components of Stewardship BCD studied in the paper. Stewardship of BCD is an active, conscious engagement in the shaping of assemblages of biodiversity, while lived BCD in some ways can be said to be more passive and primarily mediated through perceptions. Stewardship of BCD overlaps with the analysis of lived BCD in its interest in motivations, values, actions, norms, etc. Moreover, it  | Categorical (Binary 0/1 for each category) | Coding               |

|                                 |                        |  |  |        |
|---------------------------------|------------------------|--|--|--------|
|                                 |                        | emphasizes the bonding with nature. Beliefs / Taboos / Religion, Cosmvision / Worldview Values, HNC (human-nature connectedness), Cultural identity, Sense of place, Sense of community, Sense of responsibility, Customary norms/ Customary institutions, Legal norms / Policy / Institutions or other.   |  |        |
| <b>Current efforts /actions</b> | Current effort /action | Different actions, efforts or strategies conducted in the context of the study for BCD conservation or enhancement.<br>Research/Inventory of BCD, Implementation in other studies/areas, Law/Norms, Policy, Investment/Funding/Incentives (money), Protection actions, Management/Livelihood related actions/Conservation actions, Restoration actions, Stakeholder engagement/Collaboration between different stakeholders/Participation, Knowledge exchange or inclusion/Dialogue/Discussion, Education/Knowledge transmission, Ecotourism Raising awareness/Information outreach/promotion, Valorization/Adding value/Recognition of rights, Organization/Cooperativism/Collective actions, Activism/Protest/Defense/Empowerment, Support, Sustainability actions or other.   | Categorical (Binary 0/1 for each category) | Coding |
|                                 | Current actors         | Actors within the science-policy-society interface (López-Rodríguez et al. 2020) that have been carrying out the efforts. Science, Policy, Society, Science-Policy, Science-Society, Policy-Society, Science-Policy-Society.   | Categorical (Binary 0/1 for each category) | Coding |
| <b>Future efforts /actions</b>  | Future effort /action  | Different actions, efforts or strategies that need to be conducted in the future for BCD conservation or enhancement.<br>Research/Inventory of BCD, Implementation in other studies/areas, Law/Norms, Policy, Investment/Funding/Incentives (money), Protection actions, Management/Livelihood related actions/Conservation actions, Restoration actions, Stakeholder engagement/Collaboration between different stakeholders/Participation, Knowledge exchange or inclusion/Dialogue/Discussion, Education/Knowledge transmission, Ecotourism Raising awareness/Information outreach/promotion, Valorization/Adding value/Recognition of rights, Organization/Cooperativism/Collective actions, Activism/Protest/Defense/Empowerment, Support, Sustainability actions or other. | Categorical (Binary 0/1 for each category) | Coding |
|                                 | Future actors          | Actors within the science-policy-society interface (López-Rodríguez et al. 2020) that will be carrying out the future actions/efforts suggested. Science, Policy, Society, Science-Policy, Science-Society, Policy-Society, Science-Policy-Society.  | Categorical (Binary 0/1 for each category) | Coding |

During the data extraction and coding processes some papers will be found irrelevant and not providing information about the categories selected for analysis. All papers providing poor or no information for more than a half of the main categories will be excluded in a final decision process.

The data and code will be uploaded to an online open access data repository such as GitHub in an Excel format. Furthermore, the final list of included and excluded papers (*Appendix S2*), and the guidelines for screening (*Appendix S1*) and coding (*Appendix S2*) will also be uploaded in the same platform.

### **3.5 Study mapping and presentation of results**

Finally, the search and screening process will be summarized in the form of a ROSES diagram (Haddaway et al. 2018) according to reporting standards set by the Collaboration for Environmental Evidence for systematic maps (2022). ROSES diagrams are similar to PRISMA diagrams (<http://www.prisma-statement.org/PRISMAStatement/FlowDiagram>) seen in other fields of systematic review and mapping as they report on how many search records were found, included and excluded at each search and screening step in addition to detailed reasoning for exclusions, but in the case of ROSES, especially designed for environmental sciences. The ROSES diagram presented below (*Figure 1*) is an adaptation of the ROSES standards for the kind of mapping done in this study.

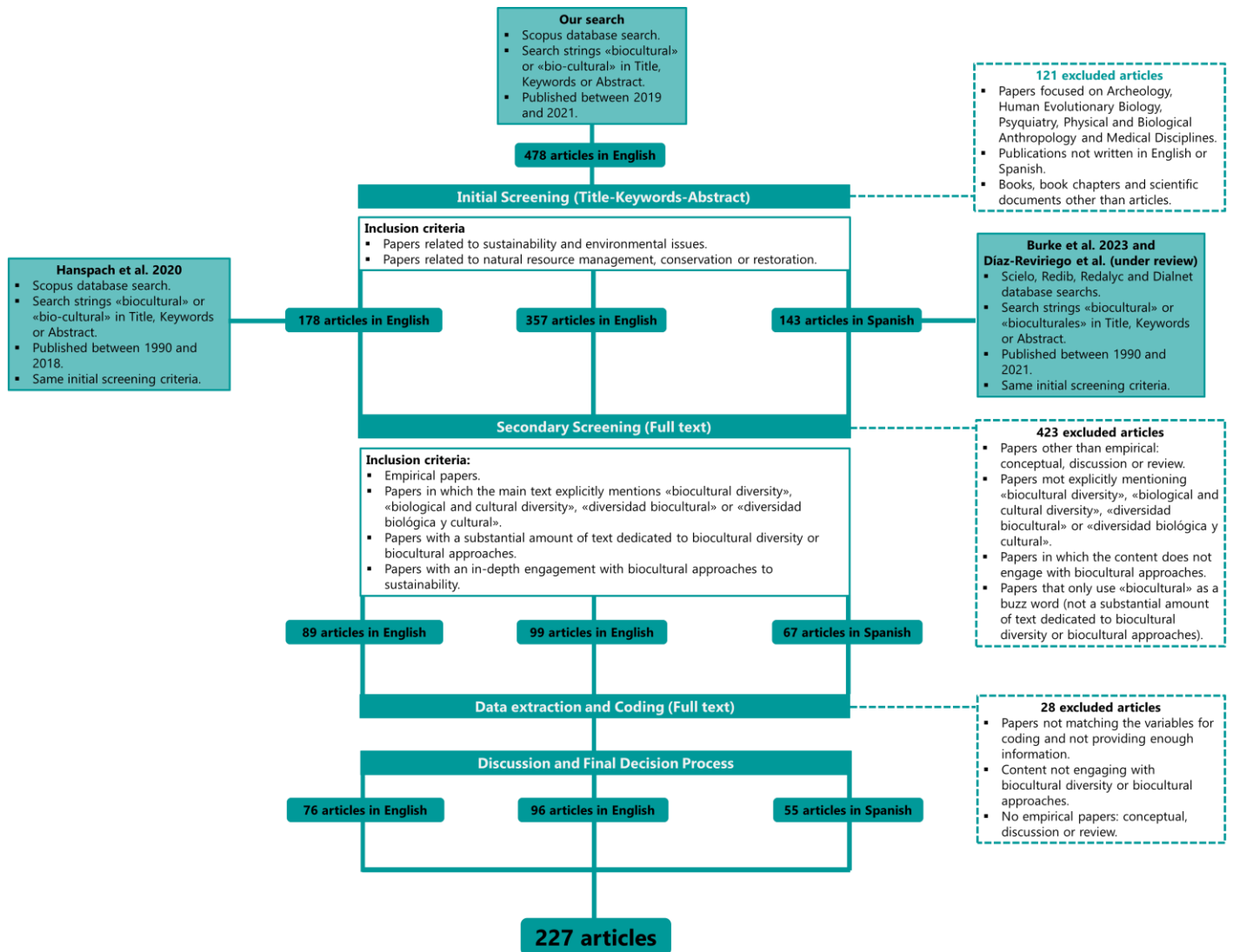


Figure 1. ROSES flow diagram.

We will show the contents of the systematic map database in an Evidence Atlas (<https://estech.shinyapps.io/eviatlas/>) or QGIS web map, allowing us to display the content in an interactive, web-based GIS that shows all meta-data and coding on a cartographic map (Haddaway et al. 2019).

We will use descriptive plots and tables in order to show the number of studies identified across the different categories described previously. This will allow us to identify knowledge gaps and clusters. Not all categories will be analyzed in depth. Only the ones helping us to answer our research questions and providing the most interesting results would be addressed in the future systematic map paper that we are planning to write and publish.

#### 4. – CONFLICT OF INTERESTS

The authors declare that they have no competing interests.

#### 5. - ACKNOWLEDGEMENTS

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#### 6. - AUTHOR CONTRIBUTIONS

IOU has developed and written the protocol. The rest of the authors have contributed to the protocol development process providing insights according to their expertise. IOU and ASL will be conducting the screening, data extraction and coding processes. IOU, ASL and JH will be checking the agreement during the screening process and carrying out the pilot meta-data extraction study. JH, CQS and AJC will be supervising the whole process and participating in periodic meetings for discussion.

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