

Mapping of international scientific collaborations in the field of biodiversity and transformative change



An analysis of transnational collaboration for the period 2013-2023



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The Biodiversa+ partners SEPTEMBER 2024

Biodiversa+ currently gathers 81 partners from 41 countries:

- 1. AKKSHI, National Agency for Scientific Research and Innovation, Albania
- 2. MTE_AL, Ministry of Tourism and Environment Albania, Albania
- 3. NAPA, National Agency of Protected Areas, Albania
- BMBWF, Federal Ministry of Education, Science and Research, Austria
- 5. **FWF**, Austrian Science Fund, Austria
- 6. EAA, Umweltbundesamt, Austria
- 7. **BelSPO**, Belgian Science Policy Office, Belgium
- 8. **F.R.S.-FNRS**, Fonds De La Recherche Scientifique, Belgium
- 9. **FWO**, The research Foundation Flanders, Belgium
- 10. **1SPW-ARNE**, Service public de Wallonie (Agriculture-Ressources naturelles-Environnement), Belgium
- 11. **1VLO**, Vlaams gewest / Flemish region, Belgium
- 12. **1BNSF**, Bulgarian National Science Fund, Bulgaria
- 13. **ExEA**, Executive Environment Agency, Bulgaria
- 14. **Moew**, Ministry of Environment and Water, Bulgaria
- 15. MESD, Ministry of Economy and Sustainable Development, Croatia
- 16. **MOECSY**, Cyprus Ministry of Education, Culture, Sports and Youth, Cyprus
- 17. NCA CZ, Národní klastrová asociace, Czech Republic
- 18. **MoE CR**, Ministry of the Environment, Czech Republic
- 19. **TA CR**, Technologicka Agentura Ceske Republiky, Czech Republic
- 20. **IFD**, Innovation Fund Denmark, Denmark
- 21. MoE of DK, Ministry of Environment of Denmark, Denmark
- 22. **ETAg**, Estonian Research Council, Estonia
- 23. **MEM**, Ministry of Rural Affairs of the Republic of Estonia, Estonia
- 24. **MoE_EE**, Estonian Ministry of the Environment, Estonia
- 25. GRANSKINGARRADID, Granskingarráðið, Faroe Island
- 26. **MoE_FI**, Ministry of the Environment, Finland
- 27. **RCF**, Research Council of Finland, Finland
- 28. **ANR**, Agence Nationale de la Recherche, France
- 29. **FRB**, Fondation pour la Recherche

- sur la Biodiversité, France
- 30. **MTECT**, Ministère de la Transition Ecologique et de la Cohésion des Territoires, France
- 31. **OFB**, Office Français de la Biodiversité, France
- 32. **MEPA**, Ministry Of Environmental Protection And Agriculture, Georgia
- 33. **SRNSFG**, Shota Rustaveli National Science Foundation, Georgia
- 34. **BfN**, Federal Agency for Nature Conservation, Germany
- 35. **BMBF**, Bundesministerium für Bildung und Forschung, Germany
- DFG, Deutsche Forschungsgemeinschaft e.V. (German Research Foundation), Germany
- 37. DLR, DLR Projektträger, Germany
- 38. VDI/VDE-IT, VDI/VDE Innovation + Technology GmbH, Germany
- 39. **GSRI**, General Secretariat for Research and Innovation, Greece
- 40. **NKFIH**, Nemzeti Kutatási, Fejlesztési és Innovációs Hivatal, Hungary
- 41. Rannis, Icelandic Centre for Research, Iceland
- 42. DHLGH, Department of Housing, Local Government and Heritage, Ireland
- 43. **EPA**, Environmental Protection Agency, Ireland
- 44. MOEP, Ministry of Environmental Protection, Israel
- 45. **MASE**, Ministry of Environment and Energy Security, Italy
- 46. **MUR**, Ministry of Universities and Research, Italy
- 47. **PROV BZ**, Autonomous Province of Bolzano/Bozen South Tyrol, Italy
- 48. **RKS**, Environmental Protection Agency, Kosovo
- 49. **LCS**, Latvian Council of Science, Latvia
- 50. **MoES**, Ministry of Education and Science Republic of Latvia, Latvia
- 51. **LMT**, Lietuvos mokslo taryba, Lithuania
- 52. **MECSD**, The Ministry of the Environment, Climate and Sustainable Development, Luxembourg
- 53. NARD, Agentia Nationala Pentru Cercetare Si Dezvoltare, Moldova
- 54. **EPA_M**, Environment Protection Agency of Montenegro, Montenegro
- 55. **MENFPESRS**, Ministry of National Education, Vocational Training, Higher Education and Scientific

Research, Morocco

- 56. LNV, Ministry of Agriculture, Nature and Food quality, The Netherlands
- 57. **NWO**, The Dutch Research Council, The Netherlands
- 58. **NEA**, Norwegian Environment Agency, Norway
- 59. **RCN**, Research Council of Norway, Norway
- 60. NCN, Narodowe Centrum Nauki, Poland
- 61. **FCT**, Fundação para a Ciência e a Tecnologia, I.P., Portugal
- 62. **FRCT**, Fundo Regional para a Ciência e Tecnologia, Portugal
- 63. **UEFISCDI**, Executive Agency for Higher Education, Research, Development and Innovation Funding, Romania
- 64. MoER SR, Ministry of Environment of the Slovak Republic, Slovakia
- 65. **SAS**, Slovak Academy of Sciences, Slovakia
- 66. **MIZS**, Ministry of Education, Science and Sport, Slovenia
- 67. **DSI**, Department of Science and Innovation, South Africa
- 68. **AEI**, Agencia Estatal de Investigación, Spain
- 69. **CDTI**, Centro para el Desarrollo Tecnológico Industrial, Spain
- 70. **DACC**, Departament d'Acció Climàtica, Alimentació i Agenda Rural, Spain
- 71. **FECYT**, Fundación Española para la Ciencia y Tecnología, Spain
- 72. FB, Fundación Biodiversidad, Spain
- Formas, Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, Sweden
- 74. **SEPA**, Swedish Environmental Protection Agency, Sweden
- 75. **SwAM**, Swedish Agency for Marine and Water Management, Sweden
- 76. **SNSA**, Swedish National Space Agency, Sweden
- 77. **SNSF**, Swiss National Science Foundation, Switzerland
- MHESRS, Ministry of Higher Education and Scientific Research, Tunisia
- 79. **TAGEM**, General Directorate of Agricultural Research and Policies, Türkiye
- 80. **TUBITAK**, Scientific and Technological Research Council of Turkey, Türkiye
- 81. NERC, Natural Environment Research Council, United Kingdom

List of acronyms:

CBD - Convention on Biological Diversity

- DG Directorate General
- ERA European Research Area
- EU European Union
- IPBES Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
- LAC Latin America and Caribbean
- OCT Outermost Countries and Territories
- OR Outermost Regions
- UN United Nations
- WoS Web of Science
- TC Transformative Change
- PB only publications on the topic of "biodiversity"
- PBKW publications filtered based on the 39 keywords of biodiversity (excluding "biodiversity" itself)
- PBKWTC publications filtered based on the 73 "transformative change" keywords
- SDG Sustainable Development Goals

What is Biodiversa+

The European Biodiversity Partnership, Biodiversa+, supports excellent research on biodiversity with an impact for policy and society. Connecting science, policy and practise for transformative change, Biodiversa+ is part of the European Biodiversity Strategy for 2030 that aims to put Europe's biodiversity on a path to recovery by 2030. Co-funded by the European Commission, Biodiversa+ gathers 81 partners from research funding, programming and environmental policy actors in 41 European and associated countries to work on 5 main objectives:

- **1.** Plan and support research and innovation on biodiversity through a shared strategy, annual joint calls for research projects and capacity building activities
- 2. Set up a transnational network of harmonised schemes to improve monitoring of biodiversity and ecosystem services across Europe
- 3. Contribute to high-end knowledge for deploying Nature-based Solutions and valuation of biodiversity in the private sector
- 4. Ensure efficient science-based support for policymaking and implementation in Europe
- 5. Strengthen the relevance and impact of pan-European research on biodiversity in a global context

For more information: www.biodiversa.eu

Table of contents

6

8

14

38

INTRODUCTION

METHODOLOGY

RESULTS

CONCLUSIONS

Introduction

Humanity is currently confronting the simultaneous and interconnected global crises of biodiversity loss. These crises share common human-induced root causes, such as changes in land and sea use, direct exploitation of organisms, climate change, pollution, and invasion of alien species. (IPBES 2019¹).

There are still substantial gaps in our understanding of biodiversity and its relationship with society. Even when strong evidence exists on measures to prevent biodiversity loss, it is often not reflected in policy and management decisions (IPBES 2019).

As a result, there is an urgent need to drive rapid, significant, and coordinated transformative change (CBD 2022, European Commission 2021, IPBES 2019). This change must consider the environmental, social, cultural, behavioural, economic, political, health, and justice aspects of sustainability. Therefore Biodiversa+Partnership launched a dedicated call² on Biodiversity and Transformative Change in 2024.

The scope of this mapping is to analyse the level of international collaborations in relation to the intersection of the two fields: biodiversity³ and transformative change⁴. Additionally, the report aims to present the research priorities based on the taxonomies available on the Web of Science (WoS) platform. Bibliographic analyses are a valuable tool for evaluating research collaborations on biodiversity and transformative change between the European Research Area (ERA) and other global regions. By measuring scientific cooperation between regions, these analyses offer information into the structure and dynamics of research networks. Examining co-authoring networks, their temporal trends, geographical distribution, and subject areas enables the assessment of initiatives designed to promote international collaboration.

In this mapping covering the 2013-2023 period, Biodiversa+ reports the results obtained from the analysis of the publications involving authors from the European research area and other regions of the world published to study transnational research collaboration on biodiversity and transformative change.

^{1.} IPBES (2019): Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

^{2.} https://www.biodiversa.eu/2024/06/11/2024-2025-joint-call/

^{3.} **Biodiversity** is defined here according to the Convention on Biodiversity Diversity as "the variety among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".

^{4.} The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services - IPBES, defines **transformative change** as "Fundamental system-wide reorganisation across technological, economic and social factors, including paradigms, goals and values needed for the conservation and sustainable use of biodiversity" (IPBES 2019).



Methodology



Bibliographic review

This analysis utilised data from the InCites Product of the Web of Science Platform to examine scientific literature published in Core Collection indexed journals (all publications are in English) over the ten-year period from 2013 to 2023 (not all publications for the year 2023 had been indexed in the WoS platform at the time of the analysis, June - July 2024).

There were retrieved all the publications with at least one author affiliated in one of the eight world regions as defined by the following taxonomy:

Countries in Africa: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Democratic Republic of Congo, Djibouti, Egypt, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Ivory Coast, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Republic of the Congo, Rwanda, São Tomé and Príncipe, Senegal, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Tanzania, Togo, Uganda, Zambia, Zimbabwe.

Countries in Asia: Afghanistan, Armenia, Azerbaijan, Bahrain, Bangladesh, Bhutan, Brunei, Cambodia, India, Indonesia, Iran, Iraq, Japan, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Laos, Lebanon, Malaysia, Maldives, Mongolia, Myanmar, Nepal, North Korea, Oman, China, Pakistan, Palestine, Philippines, Qatar, Saudi Arabia, Singapore, South Korea, Sri Lanka, Syria, Taiwan, Tajikistan, Thailand, Timor Leste, Turkmenistan, United Arab Emirates, Uzbekistan, Vietnam, Yemen.

Countries in the **ERA**: *EU member states*: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark (excl. OCTs and ORs), Estonia, Finland, France (excl. OCTs and ORs), Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands (excl. OCTs and ORs), Poland, Portugal (excl. OCTs and ORs), Romania, Slovakia, Slovenia, Spain (excl. OCTs and ORs), Sweden; and *associated countries* ⁵: Albania, Andorra, Bosnia and Herzegovina, Georgia, Israel, Norway, Liechtenstein, Macedonia, Moldova, Monaco, Montenegro, Morocco, North Macedonia, Norway, San Marino, Serbia, Switzerland, Tunisia, Turkey, United Kingdom⁶ (excl. OCTs and ORs), Vatican.

Countries in Latin America and the Caribbean (LAC) region: Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Falkland Island, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Seychelles, Saint Kitts and Nevis, Saint Lucia, Saint Vincent, Suriname, Trinidad and Tobago, Uruguay, Venezuela.

Countries in the **North America** region: Canada, United States of America.

Countries of **Oceania** region: Australia, Cook Islands, Fiji, Kiribati, Marshall Islands, Micronesia, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu.

Countries of **Other Europe** region: Belarus, Kosovo, Russia, Ukraine.

Countries of **OCTs and ORs**: Anguilla, Ascension Island, Bonaire, British Indian Ocean Territory, British Virgin Islands, Curaçao, Falkland Islands, Faroe Islands, French Guiana, French Polynesia, Gibraltar, Greenland, Montserrat, New Caledonia, Réunion, Saint Helena, Saint-Barthélemy, Saint-Martin, Sint Maarten, The Netherlands Antilles, Tristan da Cunha, Turks and Caicos Islands.

The study was elaborated to identify scientific publications related to the fields of biodiversity and transformative change.

In order to obtain the data set relevant for the analysis the following keywords were used to identify publications corresponding to research collaboration on biodiversity and transformative change:

^{5.} https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/common/guidance/list-3rd-country-participation_horizon-euratom_en.pdf

^{6.} The United Kingdom (England, Scotland, Wales, North Ireland) is included in the ERA

Biodiversity keywords:

- 1. Amphibian diversity / Diversity of amphibian
- 2. Animal diversity / Diversity of animal
- 3. Bacteria diversity / Diversity of bacteria
- 4. Biodiversity
- 5. Biodivers
- 6. Biological conservation
- 7. Biological diversity, / Diversity of biology
- 8. Biological invasion
- 9. Bird diversity / Diversity of bird
- 10. Ecological service
- 11. Ecosystem diversity / Diversity of ecosystem
- 12. Ecosystem service
- 13. Environmental impact statement / Statement of environmental impact
- 14. Fish diversity / Diversity of fish
- 15. Frog diversity / Diversity of frog
- 16. Functional diversity
- 17. Functional group
- 18. Functional trait
- 19. Functional type
- 20. Fung diversity / Diversity of fung

Transformative Change keywords*:

- 1. Awareness raising
- 2. Behaviour
- 3. Biodiversity
- 4. Conceptualisations of biodiversity
- 5. Consumption
- 6. Decision-making
- 7. Ecological footprint
- 8. Ecosystem services
- 9. Nature's contribution to people
- 10. Economics
- 11. Equitable distribution
- 12. Equitable sharing
- 13. Fiscal barriers
- 14. Harmful policies/subsidies/ incentives
- 15. Governance strategies
- 16. Governance systems
- 17. Institutional arrangements
- 18. Science–policy interface
- 19. Living in harmony with nature

in the development of the Biodiversa+ BiodivTransform call.

- 20. Justice
- 21. Leverage points
- 22. Lifestyles
- 23. Lifestyle changes
- 24. Monetary valuation

- 25. Multiple values- value systems
- 26. Natural capital accounting
- 27. Non-monetary valuation
- 28. Participation
- 29. Power
- 30. Regulatory barriers
- 31. Social barriers
- 32. Social-ecological transformation
- 33. Social-ecological transition
- 34. Social-ecological traps
- 35. Social learning
- 36. Societal transformation
- 37. Collective commitment
- 38. Collaborative efforts
- 39. System-wide reorganisation
- 40. Fundamental transformation
- 41. Coherence
- 42. Coordinated approach
- 43. Integrated actions
- 44. Societal values
- 45. Sustainable development
- 46. Sustainability transitions
- 47. Sustainable transition
- 48. Systems thinking
- 49. Transformative change

*The keywords for the field of transformative change were obtained through a consultation process with experts involved

- 21. Genetic diversity, / Diversity of genetic
- 22. Genetic resource / Resources of genetic
- 23. Habitat conservation / Conservation of the habitat
- 24. Habitat diversity / Diversity of habitat
- 25. Insect diversity / Diversity of insect
- 26. Invasive species
- 27. Landscape diversity / Diversity of landscape
- 28. Mammal diversity / Diversity of mammal
- 29. Microbial diversity / Diversity of microbial
- 30. Phylogen
- 31. Plant diversity / Diversity of plant
- 32. Reptile diversity / Diversity of reptil
- 33. Species conservation / Conservation of species
- 34. Species diversity / Diversity of species
- 35. Species loss / Loss of species
- 36. Species richness / Richness of species
- 37. Taxonom
- 38. Tree diversity / Diversity of tree
- 39. Virus diversity, / Diversity of virus
- 40. Weed diversity / Diversity of weed
 - 50. Vested interests
 - 51. Path dependence
 - 52. Planetary boundaries
 - 53. Earth system boundaries
 - 54. Responsibility
 - 55. Tele-coupling
 - 56. Tipping points
 - 57. Thresholds

61. Scenarios

63. Scaling

62. Localization

64. Financial risks

66. Supply chain

69. Co-learning

71. Dialogue

67. Industrial ecology

68. Nature positive

72. Value pluralism

73. All-inclusiveness

58. Planetary well-being59. Interlinkage, nexus

60. Tradeoffs/synergies

65. Business transformation

70. Knowledge co-production

The selection mechanism for the analysed publications ⁷ consisted of three distinct stages. In the first stage, from the total publications indexed in the WoS Core Collection (comprising the Science Citation Index Expanded - SCI-EXPANDED, Social Sciences Citation Index - SSCI, Arts & Humanities Citation Index - A&HCI, and Emerging Sources Citation Index - ESCI), only publications on the topic of "biodiversity" (PB) were filtered. In the second stage, the publications were filtered based on the keywords of biodiversity (excluding "biodiversity" itself) (PBKW). In the final stage, the PBKW publications were filtered based on the "transformative change" keywords, retrieving the PBKWTC publications that will be the base of the below analysis.

These publications were scientometric analysed by applying a set of criteria in the "Analyse Results" and InCites benchmarking & analytics sections, available in the new interface of the Web of Science platform (launched in 2021 and continuously updated). The following information was identified:

- Research disciplines (list of available taxonomies⁸ in WoS such as: Macro Citation Topics⁹, Meso Citation Topics¹⁰, Micro Citation Topics¹¹)
- Affiliate countries/regions

In order to identify the number of publications from each region, the countries that changed their names during the analysed period were renamed and regions or countries under the administration/government of another country/ region were regrouped. The platform was subsequently queried on the new groupings according to the "countries" criterion.

In the whole mapping report, each region has an individual colour matching the HEX code used by Biodiversa+ network (see details in the following table).

| Region* | Colour | | HEX Code | | |
|--------------------|--------|-----|----------|-----|---------|
| Africa | | 192 | 0 | 0 | #C00000 |
| Asia | | 255 | 192 | 0 | #FFC000 |
| ERA | | 2 | 164 | 167 | #02a4a7 |
| ERA - OCTs and ORs | | 175 | 238 | 238 | #afeeee |
| LAC | | 152 | 192 | 30 | #98c01e |
| North America | | 0 | 112 | 192 | #0070C0 |
| Oceania | | 112 | 48 | 160 | #7030A0 |
| Other Europe | | 16 | 59 | 96 | #103b60 |

Table 1. World Regions colours. *by alphabetical order.

^{7.} Publications - inquiry based on the following fields: titles, keywords and abstracts available in WoS platform

^{8.} Citation Topics are algorithmically derived citation clusters (using an algorithm developed by CWTS, Leiden). This is a three-level hierarchical document-level classification system. The three levels of the hierarchy and their content according to the 2024 clustering: https://incites.help.clarivate.com/Content/Research-Areas/citation-topics.htm

^{9.} Macro-topics, the majority of the documents are assigned to the same Macro-topic with an average stability of 96.88%, being Clinical & Life Sciences the most conserved one (99.06% documents' stability) and Arts & Humanities the one with the higher change (94.15% document's stability). None of the Macro-topic label names has changed.

^{10.} Meso-topics, the documents' stability is higher than 90%. The 314 Meso-topic, Social Work, has been re-labeled to 314-Homelessness & Human Trafficking.

^{11.} Micro-topics are the Citation Topics with a higher change in the content size with Micro-topics increasing the content and others reducing it. However most have maintained a stable number of documents. For Micro-topics, 160 have changes in the label name, and 13 new have been added as result of the re-clustering.

Analysis and mapping of co-authoring and co-publication networks

After filtering WoS publications the data was downloaded in .txt and .csv format. These data were imported into Excel to produce relevant graphs.

International networks of researchers were analysed based on the address of the authors' affiliations included in their research papers. In case of multiple affiliations the publication is counted for each country present in these affiliations. The information on the countries of scientists co-authoring a given paper was transformed into a link between countries collaborating in this paper.

Finally, a triangular matrix was computed to identify the links between each pair of countries based on the number of papers co-authored by these countries.

The co-publication network analysis and mapping was performed using the open source Gephi software.

Two-dimension spatial mappings were performed using the Force-Atlas algorithm in Gephi. This algorithm creates a visual representation of nodes (countries) connected by edges based on co-authorship according to the following rules: 1) node size represents the number of publications, 2) all nodes are attracted to the centre, i.e., the country with the highest number of publications, 3) all nodes repel each other to prevent visual overlapping of the nodes, 4) all nodes that are connected by an edge attract each other, according to the weight of the edge, i.e., the number of publications with co-authorship between the two countries/regions. Two nodes are thus spatially closer if authors of these countries strongly publish together.

The InCities word cloud visualisation was used to represent the research subdomains from the micro topics (taxonomy with 2488 subdomains).



Results



Data set configuration

Applying the selection algorithm presented above in the methodology, the final number of 13,823 publications, represented the PBKWTC dataset analysed in the following mapping exercise (Figure 1). The figure indicates the number of PBKWTC publications in comparison to all, PB and PBKW publications.

In the first stage, from a total of 31,010,401 publications in the 2013-2023 period indexed in the WoS Core Collection (comprising the Science Citation Index Expanded - SCI-EXPANDED, Social Sciences Citation Index - SSCI, Arts & Humanities Citation Index - A&HCI, and Emerging Sources Citation Index - ESCI), only publications on the topic of "biodiversity" (PB) were filtered, resulting in 143,630 publications. In the second stage, the publications were filtered based on the 39 keywords of biodiversity (excluding "biodiversity" itself) (PBKW), obtaining 64,568 publications. In the final stage, the PBKW publications were filtered based on the 73 "transformative change" keywords, retrieving 13,823 publications (PBKWTC).



Figure 1. Publication filtering mechanism at the intersection of biodiversity and transformative change keywords.



The below Figure 2 displays the distribution of all publications across 10 macro topics in the InCites analysis software used for the period 2013-2023 and it

can be observed that the Arts & Humanities and Social Sciences fields are represented with a percentage of 12,9% in the articles included in the dataset.



Units: Web of Science Documents

Indicators: Web of Science Documents.Time Period:2013-2023. Schema:Citation Topics. Dataset: InCites Dataset InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024.Export Date: Oct 7, 2024.



Applying the PBKWTC filter it was obtained a specific distribution of the weights of the 10 macro topics highlighted in the image below (Figure 3). In this new configuration **Agriculture, Environment, and Ecology** dominate the PBKWTC dataset, making up 87.3% of the publications (while it has only 9.5% of all publications), this shows that research related to biodiversity and transformative change is heavily concentrated in this domain. This is followed by the **Social Sciences** domain that makes up 7.8% of the dataset. This is

lower than its representation in the overall publications (10.8%), but it still plays an important role in addressing the societal aspects of biodiversity and transformative change.

Together, these two domains account for 95.1% of the PBKWTC dataset, indicating that biodiversity and transformative change research is strongly interdisciplinary.



Units: Web of Science Documents

Indicators: Web of Science Documents.Time Period:2013-2023. Schema:Citation Topics. Dataset: BPKWTC.new InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024.Export Date: Oct 7, 2024.

Figure 3. Distribution of the PBKWTC Dataset by Macro Topics. (PBKWTC - Publication filtered at the intersection of biodiversity and transformative change keywords) Going more in depth (Figure 4), the classification of the 13,823 PBKWTC articles was made by using the taxonomies available on the WoS platform: Research Areas (100 out of 152 subdomains), WoS categories (145 out of 254 subdomains), Meso topics (130 out of 326 subdomains), Micro Topics (387 out of 2.488 subdomains).





The above graph illustrates the percentage distribution of subdomains in which PBKWTC publications have been found, relative to the total number of subdomains for each analysed taxonomy. As the taxonomies become more detailed and include a larger number of subdomains, there is a noticeable decrease in the percentage of subdomains containing PBKWTC publications. This occurs because more complex and precise taxonomies tend to encompass and refine broader domains, leading to a wider dispersion of publications across a larger range of subdomains. By calculating the percentage weights of the sub-domains into which the PBKWTC dataset falls for each taxonomy, the graph in Figure 4 was elaborated. The coverage of 15.55% of the taxonomy's subdomains (for micro topics) with PBKWTC publications indicates the multidisciplinary relevance of the analysed dataset, highlighting a significant global concern for biodiversity and transformative change.



The below figure shows the top 50 micro topics out of 387 in the PBKWTC dataset, representing the most focused research areas within biodiversity and transformative change. The breadth of these topics demonstrates that biodiversity and transformative change research encompasses a wide array of detailed and specific ecological and biological interests.



Indicators: Web of Science Documents. Time Period: 2013-2023. Schema: Citation Topics. Level: Micro. Dataset: BPKWTC.new InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024. Export Date: Oct 7, 2024.

Figure 5. Top 50 Micro topics for the PBKWTC dataset. (PBKWTC - Publication filtered at the intersection of biodiversity and transformative change keywords)

In order to have a more general image of these interests, the mapping presents below the rankings of the analysed taxonomies as follows:

• Figure 6 presents the top 10 meso topics out of a total of 130 covered by the PBKWTC dataset, the meso topics are broader than micro topics but still

more specific than macro topics. The leading meso topic in this dataset is **Forestry**, reflecting the importance of forests in biodiversity and transformative change research, followed by **Marine Biology** and **Entomology** (the study of insects) in the next two spots.



Indicators: Web of Science Documents.Time Period:2013-2023. Schema:Citation Topics. Level:Meso. Dataset: BPKWTC.new InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024.Export Date: Oct 7, 2024.

Figure 6. Top 10 Meso topics for the PBKWTC dataset.

(Meso topics are preceded by a code consisting of a number from 1-10 corresponding to the macro topic from which it originates and the order number of the meso topic in the taxonomy; PBKWTC - Publication filtered at the intersection of biodiversity and transformative change keywords)

• Figure 7 (below) ranks the top 10, out of 145, Web of Science Categories covered by the PBKWTC dataset, where **Ecology** stands out as the leading category in terms of the number of publications signifying its central role in studies that address biodiversity and transformative change. Followed closely by **Environmental Sciences** and **Biodiversity Conservation**, illustrating that research is heavily focused on understanding and preserving ecological systems.



Figure 7. Top 10 Web of Science Categories for the PBKWTC dataset. (PBKWTC - Publication filtered at the intersection of biodiversity and transformative change keywords)

 Figure 8 presents the top 10 out of a total of 100 Research Areas covered by the PBKWTC dataset.
 Environmental Sciences and Ecology rank first among research areas, which is expected given the environmental focus of biodiversity studies. This is followed by **Biodiversity Conservation** that ranks second, reinforcing the urgency of conserving species and ecosystems amidst ongoing environmental threats.



Figure 8. Top 10 Research Areas for the PBKWTC dataset.

(PBKWTC - Publication filtered at the intersection of biodiversity and transformative change keywords)

Temporal and spatial trends of biodiversity and transformative change

The mapping provides a detailed analysis of temporal and spatial trends in biodiversity and transformative change publications, with a focus on various regions, Sustainable Development Goals (SDGs), and specific countries.

Over the decade (2013-2023), a total of 13,823 publications related to biodiversity and transformative change (PBKWTC) were published worldwide. A consistent upward trend in the number of published articles can be observed over the period from 2013 to 2021 (Figure 9), this growth likely reflects increasing global awareness and academic focus on these topics. The decline in PBKWTC publications during the 2022-2023 period mirrors a general trend of decreasing publications in journals indexed by the Web of Science (WoS). It is also important to note that, at the time of mapping, the year 2023 had not been fully indexed in the WoS database, which may have contributed to the observed reduction.



Figure 9. Trend in biodiversity and transformative change publications.

The PBKWTC dataset covers all of the Sustainable Development Goals (SDG), according to the report generated by InCites, as shown in Figure 10. The sizes of the boxes are proportional to the number of PBKWTC publications associated with each SDG, and the detailed values can be found in Table 2. There was a particular focus on:

- Life on Land (SDG 15): Most PBKWTC publications (11,278) are related to land biodiversity, indicating significant attention to terrestrial ecosystems.
- Life Below Water (SDG 14) and Climate Action (SDG 13): These topics also have a high number of publications (8,647 and 7,312, respectively), showing a strong research focus on marine biodiversity and climate issues.





Box size indicates number of Web of Science Documents ①

Indicators: Web of Science Documents. Time Period: 2013-2023. Schema: Sustainable Development Goals. Dataset: BPKWTC.new InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024. Export Date: Oct 7, 2024.

Figure 10. Tree Map representation of PBKWTC data set on SDG. (PBKWTC - Publication filtered at the intersection of biodiversity and transformative change keywords)

 Table 2. No. of PBKWTC publications on SDG.

 (PBKWTC - Publication filtered at the intersection of biodiversity and transformative change keywords)

| SDG | PBKWTC publications | |
|--|---------------------|--|
| 15 Life on Land | 11278 | |
| 14 Life Below Water | 8647 | |
| 13 Climate Action | 7312 | |
| 02 Zero Hunger | 3272 | |
| 11 Sustainable Cities and Communities | 2174 | |
| 06 Clean Water and Sanitation | 1887 | |
| 03 Good Health and Well-being | 1342 | |
| 01 No Poverty | 397 | |
| 12 Responsible Consumption and Production | 264 | |
| 07 Affordable and Clean Energy | 247 | |
| 09 Industry, Innovation and Infrastructure | 223 | |
| 08 Decent Work and Economic Growth | 105 | |
| 04 Quality Education | 30 | |
| 16 Peace and Justice Strong Institutions | 14 | |
| 10 Reduced Inequality | 8 | |
| 17 Partnerships for the Goals | 3 | |
| 05 Gender Equality | 2 | |

The distribution of biodiversity and transformative change publications across different World Regions, as defined by the methodology, indicates that the ERA ranks highest, with North America following closely in terms of the number of publications (Figure 11).



Figure 11. The distribution of biodiversity and transformative change publications on World Regions.

European Research Area (ERA) and North America dominate the number of PBKWTC publications, reflecting the substantial scientific and academic infrastructure in these regions. More than half of the total number of publications (13,823) include authors from the ERA. The USA leads globally with 3,399 publications, followed by the UK (2,080), Germany (1,921), and China (1,811). In this respect, these countries reflect strong commitment to biodiversity and transformative change related research. Top 5 countries, with the most published PBKWTC articles, come from 4 four different regions (North America, ERA, Asia, Oceania) out of the 8 analysed (Figure 12).



Figure 12. Global distribution of the most active countries out of PBKWTC data set. (PBKWTC - Publication filtered at the intersection of biodiversity and transformative change keywords)

Going more in depth, the figure below (Figure 13)

highlights the top 15 countries that have published the



Going more in depth, the figure below (Figure 13) highlights the top 15 countries that have published the most articles in the PBKWTC dataset. These countries are notably diverse, with representation from all continents. Countries such as France, Spain, and Italy also play key roles, being part of the Biodiversa+ partnership, the European network dedicated to biodiversity (United Kingdom (2nd place), Germany (3rd

place), France (6th place), Spain (8th place), Italy (10th place), Switzerland (11th place), the Netherlands (12th place), Sweden (13th place), South Africa (14th place), Portugal (15th place)). This regional diversity shows widespread global engagement but also suggests that the most productive research hubs remain concentrated in higher-income countries.



ndicators: Web of Science Documents. Time Period:2013-2023. Schema:Citation Topics. Location:NOT ENGLAND. Dataset: BPKWTC.new nCites dataset updated Aug 30, 2024. Includes Web of Science content indexed through Jul 31, 2024.Export Date: Sep 10, 2024.



This analysis of trends in biodiversity and transformative change publications illustrates the increasing recognition of the environmental crisis and a rising scientific commitment to addressing these issues. However, gaps in research remain, particularly in how biodiversity links to social issues, and much of the leading research remains concentrated in wealthier nations.

Transnational collaborations

Using the clustering tool in Gephi, Figure 14 illustrates the degree of collaboration between World Regions, represented by the thickness of the arches connecting each pair of regions. For example, the most productive collaboration in terms of "Highly Cited Papers" was between the ERA and North America, this suggests these two regions have

the most robust academic networks and are producing the highest number of impactful biodiversity and transformative change-related research. The next significant collaborative ties are between the ERA and Asia, followed by ERA with LAC.



Figure 14. Inter-regional collaborations.

(links between the authors' regions of the 274 "Highly Cited Papers" analysed in the PBKWTC dataset; the thickness of the lines is proportional with the number of publications; PBKWTC - Publication filtered at the intersection of biodiversity and transformative change keywords)

ERA stands out as a leader both from a quantitative perspective, in terms of the number of publications, with more than half of the total number of publications (Figure 11), and from a qualitative perspective, in terms of the most cited articles in the PBKWTC dataset (Figure 14).



The analysis of the PBKWTC data set yielded 7.740 publications with at least one author affiliated with ERA. This section examines transnational collaboration between ERA and all world regions defined above. Figure 15 illustrates the distribution with which researchers from the ERA publish on biodiversity and transformative change topics, either exclusively with other ERA authors or with authors from other world regions. The regions with the highest co-authorship rates with ERA are North America and Asia, confirming that these regions are major players in the global research ecosystem on biodiversity and transformative change.

Such transnational collaborations indicate a widespread recognition that biodiversity and transformative change issues are global in nature and require cross-border research efforts to address effectively.



Figure 15. Distribution of ERA co-authorship publications at the World Regions level. (The bars are for quantitative aspects - number of publications per each collaboration and each slide of the pie is the percentage for each collaboration from the entire PBKWTC data set; PBKWTC - Publication filtered at the intersection of biodiversity and transformative change keywords)



The below image (Figure 16) highlights, in the central part, the most visible subdomains (micro topics from the taxonomy available in InCites) found in the PBKWTC dataset.

Each box, which surrounds the central cloud, represents the collaborations between ERA and the 8 regions of the world illustrating the top 5 common subdomains of bi-regional collaborations (e.g. ERA - Africa, ERA-Oceania, ERA-North America). To identify regional priorities, arrows were used to highlight specific sub-domains (e.g. ERA-Africa with Deforestation, ERA-Asia with Microbial Biomass, ERA-Oceania with Polychaeta and Fisheries, ERA-North America with Dendrochronology, ERA-LAC with Deforestation, ERA- ERA OCTs and Ors with Ethnobotany and ERA-Other Europe with Permafrost).

It can be observed that a common denominator for all regions is the micro topic "MaxEnt ", demonstrating that modelling species niches and distributions for which this open software is used is of high importance for PBKWTC publications. MaxEnt's popularity in biodiversity and transformative change research might come from its ability to address key questions about species distribution, conservation, and the impacts of environmental changes. In publications related to transformative change, MaxEnt plays an important role in understanding how ecosystems and species distributions might alter due to shifts in human activities, governance policies, and climate adaptation strategies.

Additionally, "Ecosystem Services" is found in 7 out of the 8 regions, while "Seed Dispersal" is present in 6 out of the 8 regions of the world.

Some micro topics mirror geographical (Permafrost – ERA-Other Europe) or economic (Fisheries – ERA-Oceania and ERA-OCTs and Ors) features, which could have been expected, other results seem unexpected (Ebola Virus – ERA-OCTs and Ors, but not ERA-Africa).

It can also be noticed that the set of micro topics obtained from all articles with authors from ERA and ERA-exclusive is similar, ERAs concerns confirming the relevance of global priorities.



Figure 16. Micro topics for the PBKWTC dataset. (PBKWTC - Publication filtered at the intersection of biodiversity and transformative change keywords)

Bilateral Collaboration Analyse

This section analyses international collaborations (Figure 15) in terms of countries involved in co-authorship and meso-topic subdomains.

Table 3 highlights the most representative topics (at the meso taxonomy level) for each of the 9 types of ERA collaborations based on the PBKWTC data sets. 6 out of the 7 meso topics (Forestry, Marine Biology, Entomology, Phylogenetics & Genomics, Soil Sciences and Zoology & Animal Ecology) match with the TOP 6 meso topics of figure 6, with "Forestry" as the most prominent topic

across all collaborations. "Marin Biology" is also an important topic in all types of international collaboration being second or third in all rankings. 3 Topics (Entomology, Phylogenetics & Genomics, Zoology & Animal Ecology) show a wider spread over 3 ranking positions, whereas in "Soil Sciences" ranges from ranking position 2 (Other Europe) to below 5 (multi regions). It is worth noting the distinct priority of "Phytochemicals," which is specific to the ERA-Africa collaboration while "Phytochemicals" is not even in the TOP 10 meso topics in figure 6.

| ERA collaboration/ Top Meso Topics | Meso1 | Meso2 | Meso3 | Meso4 | Meso5 |
|---------------------------------------|----------|---------------|-----------------------------|-----------------------------|-----------------------------|
| ERA | Forestry | Marin Biology | Entomology | Soil Science | Phylogenetics & Genomics |
| North America | Forestry | Marin Biology | Phylogenetics & Genomics | Entomology | Soil Science |
| LAC | Forestry | Entomology | Marin Biology | Zoology & Animal Ecology | Phylogenetics & Genomics |
| ASIA | Forestry | Marin Biology | Soil Science | Entomology | Phylogenetics & Genomics |
| AFRICA | Forestry | Entomology | Marin Biology | Phylogenetics & Genomics | Phytochemicals |
| OCEANIA | Forestry | Marin Biology | Entomology | Phylogenetics & Genomics | Soil Science |
| Other Europe | Forestry | Soil Science | Marin Biology | Phylogenetics & Genomics | - |
| OCTs & Ors | Forestry | Marin Biology | Zoology & Animal Ecology | - | - |
| Multi regions | Forestry | Marin Biology | Entomology | Phylogenetics & Genomics | Zoology & Animal Ecology |

Table 3. Top 5 meso topics for ERA collaborations in PBKWTC data set.

(PBKWTC - Publication filtered at the intersection of biodiversity and transformative change keywords)

Figures (17-25) provide an infographic view of how ERA countries collaborate within various regions (North America, Asia, Africa, etc.) and highlight both the countries involved and the primary research topics. Each figure represents a different region, for example:

- Figure 17 focuses on exclusive collaborations within ERA countries.
- Figure 19 looks at ERA's collaborations with North America, showing the prominent countries and research areas.
- Figure 22 focuses on ERA-Africa collaborations, showcasing the unique importance of the Phytochemicals topic in this context (Table 3).

The figures and table together offer a comprehensive view of how ERA engages in scientific research across different regions and how specific research topics dominate these collaborations, giving insights into the most active countries and scientific areas.







Indicators: Web of Science Documents. Time Period:2013-2023. Schema: Citation Topics. Level: Meso. Dataset: ERA.exclusive InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024. Export Date: Oct 7, 2024.

Figure 17. ERA Exclusive collaborations (ERA-ERA)







Indicators: Web of Science Documents. Time Period: 2013-2023. Schema: Citation Topics. Level: Meso. Dataset: Multi:region.ERA. InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024. Export Date: Oct 7, 2024.

Figure 18. Collaborations ERA - Multi-Region







Indicators: Web of Science Documents. Time Period.2013-2023. Schema:Citation Topics. Level:Meso. Dataset: ERA.NorthAmerica InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024. Export Date: Oct 7, 2024.







Indicators: Web of Science Documents. Time Period: 2013-2023. Schema: Citation Topics. Level: Meso. Dataset: ERAASIA.523 InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024. Export Date: Oct 7, 2024.

Figure 20. Bi-regional collaborations ERA - Asia







Indicators: Web of Science Documents. Time Period: 2013-2023. Schema: Citation Topics. Level: Meso. Dataset: ERA.LAC InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024. Export Date: Oct 7, 2024.

Figure 21. Bi-regional collaborations ERA - LAC







Indicators: Web of Science Documents.Time Period: 2013-2023. Schema:Citation Topics. Level:Meso. Dataset: ERA.Africa InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024.Export Date: Oct 7, 2024.







Indicators: Web of Science Documents. Time Period:2013-2023. Schema: Citation Topics. Level: Meso. Dataset: ERA.Oceania InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024. Export Date: Oct 7, 2024.







Indicators: Web of Science Documents. Time Period:2013-2023. Schema: Citation Topics. Level: Meso. Dataset: ERA. OtherEurope InCites dataset updated Sep 27, 2024. Includes Web of Science content indexed through Aug 31, 2024 Export Date: Oct 7, 2024.

Figure 24. Bi-regional collaborations ERA - Other Europe







Indicators: Web of Science Documents. Time Period:2013-2023. Schema: Citation Topics. Level: Meso. Dataset: ERA.ERA.OCT.OCR InCites dataset updated Sep 27, 2024. Includes Web of Science content Indexed through Aug 31, 2024. Export Date: Oct 7, 2024.

Figure 25. Bi-regional collaborations ERA - OCTs and Ors

Conclusions

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Conclusions

The analysis demonstrates a strong trend of international collaboration in research related to biodiversity and transformative change, particularly between European Research Area (ERA) countries and other global regions. This suggests a shared global commitment to addressing biodiversity loss and promoting transformative change. The most productive collaborations were between the ERA and North America, followed by collaborations with Asia and Latin America. Co-publication and co-authorship analysis showed that the USA, UK, Germany, and China were among the top contributors globally.

Even so, global research participation shows disparities, with some regions underrepresented (Africa, Other Europe, ERA OCTs and Ors). This suggests the need for more inclusive research collaborations that engage underrepresented regions in biodiversity and transformative change research.

The European Research Area (ERA) plays an important role in these global research collaborations. ERA countries are main nodes in the network of co-authorship, indicating that they contribute significantly to the global research output in the fields of biodiversity and transformative change.

The PBKWTC (publications filtered based on biodiversity and transformative change keywords) dataset covering the 10 years period, 2013-2023, indicated that biodiversity and transformative change research is concentrated in certain disciplines, with **agriculture**, **environment**, **ecology**, and **social sciences** being the most prominent. **Forestry**, **marine biology**, and **entomology** were highlighted as key research areas within these domains.

The emphasis on transformative change within the research highlights the growing recognition that addressing biodiversity loss requires not just conservation efforts but a fundamental shift in economic, social, and political systems.

The analysis highlights modelling species niches and distributions (via **MaxEnt** software) and ecosystem services emerged as prominent micro-topics globally. Additionally, regional priorities, such as **deforestation** in Africa and **fisheries** in Oceania, highlight the local relevance of certain research topics.

The findings of this mapping study provide valuable insights for guiding future calls for research projects, promoting policy support, and enhancing international collaboration.

Overall it is seen as a very positive approach to select topics with a view towards potential applications and relevance of results both within and beyond Biodiversa+, as these offer valuable and novel insights within their theme.

How Biodiversa+ will use this analysis

Biodiversa+ will use the mapping results in several ways to enhance its work on biodiversity research and collaboration:

The study will support the development of research calls by identifying important topics and active research communities. It also provides insights into how Biodiversa+ projects on transformative change can contribute to advancing global knowledge on transformative change.

The findings highlight key areas of expertise in different regions, helping to mobilise experts and support capacity-building, including in international science-policy fora, and help support an ambitious European Union agenda on the topic of transformative change.

The collaborations identified in this analysis will guide Biodiversa+ in making strategic decisions, such as updating its research agenda and supporting the implementation of global biodiversity goals like the Kunming-Montreal Global Biodiversity Framework.

Overall, the mapping will guide Biodiversa+ in fostering international cooperation and driving impactful biodiversity research.

Reading this mapping you will...

... discover international research collaborations, focusing on publications related to biodiversity and transformative change

... learn more about key scientific topics and trends within biodiversity and transformative change



... discover research networks and subdomains on key biodiversity and transformative change topics

