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Research programmes in global change and sustainability research: what does coordination achieve?

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Large scale research programmes and networks are an increasingly prominent feature of global change and sustainability research. They aim to bring together researchers with different topical, disciplinary and geographical backgrounds around common issues of concern. Significant human and financial resources are invested in global research programmes and networks. Nevertheless, we know little about how these coordination mechanisms contribute to collaboration or the extent to which they manage to live up to high expectations. Addressing this gap, the current article combines a literature review and scientometric analysis of two large scale programmes in global change research in order to address the question 'what does science coordination achieve?' Insights from this study are relevant for identifying possible bottlenecks of science coordination as well as potentials for improved global research systems that support interdisciplinary and international collaboration.

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International collaboration and research coordination

Scientific collaboration is necessary to address research problems that stretch beyond a single disciplinary or geographical domain [1–3]. Yet, such collaboration does not always arrive spontaneously. Instead, an increasing number of formal programmes and networks aim to enhance and steer research collaboration beyond national jurisdictions and disciplinary silos.

This development is particularly prominent in the domain of global change and sustainability research. Problems of global change and sustainability are inherently complex, multi-disciplinary and cross local to global scales. Addressing such problems requires collaboration across topical, disciplinary and geographical boundaries. Yet, although scientific research on issues of global change and sustainability is relatively internationalized [4,5], international collaboration mostly takes place within the Global North [4,6], excluding large parts of the world and depriving the scientific community of considerable intellectual capacity [7,8••]. Moreover, collaboration and integration across disciplinary perspectives, although increasing, tends to be focused on related disciplines and specific issue areas [9–11].

Global research coordination is recurrently proposed as a promising mechanisms to address these deficits [5,12–15]. Over the past decades, we have seen the development of many large scale research programmes and networks in global change and sustainability research that aim to support collaboration across national and disciplinary boundaries. Examples include global change research programmes such as the International Geosphere Biosphere Programme (IGBP) and International Human Dimensions Programme (IHDP) (which are discussed in more detail later in this paper), the Man and Biosphere programme of UNESCO [16], the Resilience Alliance [17], and more recently the Sustainable Development Solutions Network (SDSN) [18] and the global research platform Future Earth: Research for Global Sustainability [19]. These programmes and networks are different in scale, focus, level of formality and funding base.[1] What they have in common is the promise to advance global change and sustainability research by enhancing collaboration.

[1] This study focusses specifically on global research programmes and networks with a coordinating mission. It distinguished these coordinating research programmes from funding programmes. Funding programmes shape research directions by directing financial resources to specific research topics and approaches. Coordinating research programmes do not necessarily have a large funding base at their disposal and instead aim to coordinate research by different means, such as setting a common research agenda, facilitating collaboration and mobilizing capacity.

It is a common assumption that 'significant global coordination' through research programmes and networks can and should improve the performance of global change and sustainability research [12]. Global research coordination is expected to enhance interdisciplinarity, international collaboration and integration of research insights [12,19–21,22•]. In other words, global research coordination may help cross the social boundaries that structure scientific knowledge production [23]. However, global coordination also comes at a cost, as it requires substantial investments of both financial as well as intellectual and human resources [24,25•]. This warrants the question whether global research programmes and networks are able to live up to the high expectations.

Given the major promises as well as costs involved, it is surprising that the coordination function of global research programmes and networks has received little critical scrutiny. Addressing this deficit, the current paper asks whether and how global research programmes manage to shape the disciplinary, geographical and conceptual composition of research undertaken under their umbrella. The paper addresses this question in two ways. First, it provides a literature review focussed on the coordination function and influence of large scale research programmes and networks ('Research Programmes as Coordination Mechanisms'). Second, it combines this review with a scientometric analysis that reviews the impact of two global research programmes on the research undertaken under their umbrella ('Science Coordination in Global Change Research'). Based on combined insights from the literature review and scientometric analysis, the paper concludes by reflecting on the question 'what does global science coordination achieve?'[2] and identifies critical issues for consideration by research programmes and networks that aim to facilitate international and interdisciplinary collaboration ('Summary and Outlook').

Research programmes as coordination mechanisms

Global science collaboration has been on the research and policy agenda since at least the mid-20th century [26]. In recent years, there is an increased focus on the role of large scale research programmes and networks in supporting science collaboration [27–30]. Scholars have identified a trend of increased delegating of coordination to research programmes and networks, both at the national and international scale [31–33]. Moreover, research coordination is increasingly viewed as a vehicle for enhancing interdisciplinary collaboration [3,34•,35–37]. Brouwer *et al.* [34•], for example, argue that coordination through research programmes has the potential to break down methodological, social and institutional boundaries between disciplines.

[2] This question was raised in a blog written by interim Director of Future Earth Frans Berkhout [12].

It is important to make a distinction here between research programmes as funding mechanisms and research programmes as coordination mechanisms. The academic literature that investigates the role and effectiveness of research programmes mostly focusses on funding mechanisms such as the European Framework Programmes [38] or research centers and networks funded by the National Science Foundation [35]. Additionally, existing research evaluates collaborative initiatives at the national level, such as Centers of Excellence or University Research Centers [39,40]. This leaves the phenomenon of global research programmes and networks as coordination mechanisms — that is, without a large funding base — relatively unexplored. Building on the existing literature, the current review points out the unique features of coordinating research programmes and networks, focusing on how they function and what they may achieve.

How does coordination through research programmes work? Coordinating research programmes and networks hold the promise to advance science by bringing together researchers with different disciplinary, geographical and institutional backgrounds around a common theme or question of concern. According to Hessels [25•], large scale research programmes can be understood as 'intermediary organizations with a coordinating mission'. They are formally established and mandated organizations that aim to establish or strengthen relationships among researchers and research systems in order to enhance their common effectiveness [22•,25•,30,41]. The term 'intermediary' refers to the position of these organizations mediating between the daily practices of researchers and the (inter)national research environments in which these practices take place [25•]. This definition of research programmes is useful because it focusses on the coordination function of research programmes and thus allows to study research programmes that do not function as funding mechanisms per se. Instead, it recognizes that coordination through research programmes may be based on a range of different tools and activities that potentially contribute to establishing or improving relations among researchers and research teams and may improve the coherence and effectiveness of a certain domain of research [32,42••].

Coordinating research programmes have multiple strategies at their disposal, including setting a common research agenda, sharing resources, mobilizing capacity, facilitating knowledge transfer and shaping funding priorities [24,30]. Doing so, they may enhance interdisciplinary collaboration, shape global research agendas and practices, contribute to the development of research domains and share research insight and solutions across different contexts [22•,25•,30,41].

A common model to describe science coordination through research programmes is the principal-agent model, which identifies research programmes as principals that delegate

tasks to researchers as agents [43]. Yet, it is increasingly argued that this delegation model does not suffice for understanding the complex relationship between coordination agencies and the actors operating under their umbrella [42••]. Instead, researchers recognize different models and mechanisms of coordination that go beyond the delegation of tasks or funding [32,42••,43,44]. Wardenaar *et al.* distinguish three ideal typical forms of research coordination: coordination by participants, when participants in the research programme or network interact on an equal basis and make decisions collectively; coordination by a lead organization, when activities and decisions are coordinated through a single participating member; and coordination by administrators, when a separate entity is set up to coordinate activities, typically including an executive director, staff and board [44].

What does research coordination achieve? While there is a strong believe in the benefits of large scale research programmes among policy-makers and research managers, only a hand full of studies have actually assessed whether research programmes serve the goals for which they are created [40]. Overall, these studies find that research programmes and networks, also without a large funding base, have the potential to enhance collaboration [16,40,41,42••,45,46]. Yet, there are some important factors to consider. First, the nature of a research domain is an important element in research coordination. Specifically, research domains where mutual dependence between scientists is high (i.e. dependence on data, ideas and research infrastructure developed by other scientists) are more conducive to coordination by formal research programmes than research domains where mutual dependence is lower, such as research domains that build on local or regional case studies [41]. Thus, while integrating research across multiple place-based projects is highly valued in global change and sustainability research, this often proves to be particularly challenging [16,22•]. Second, collaboration within research programmes tends to be based on pre-existing communities and networks [40]. This finding is supported by several case studies that found that outcomes of research programmes could at least partly be explained by self-organization rather than coordination [17,41,45]. In general, it appears that research programmes and networks often have difficulties achieving their mission when this involves steering the research domain in a new direction, for example, towards further interdisciplinary collaboration [42••,47,48]. Existing (informal) networks and collaborations are an important factor explaining the success of research coordination. Moreover, not only patterns of collaboration but also patterns of segregation tend to get reproduced by large scale research programmes and networks [47,49]. Drawing on the above, a main challenge for research coordination is to encourage collaboration beyond established networks while also achieving a certain level of integration among previously disconnected individuals and organizations [42••,45].

Overall, while the literature review provides insights on the role and relevance of research programmes as coordination mechanisms, knowledge of the actual effects and outcomes of research coordination is limited. This review is therefore extended with a scientometric analysis of two major research programmes in global change research in order to get further insights on the question 'what does science coordination achieve?'

Science coordination in global change research

The International Geosphere-Biosphere Programme (IGBP) and International Human Dimensions Programme on Global Environmental Change (IHDP) were two of the four international global change programmes directed at coordinating and integrating research on different dimensions of global environmental change.[3] IGBP operated between 1987 and 2015 under the auspices of the International Council for Science (ICSU) and aimed to stimulate international research collaboration in the domain of earth system science [50•]. IHDP ran between 1996 and 2014, sponsored by the International Council for Science (ICSU) and the International Social Science Council (ISSC), with the aim to mobilizing the social sciences and contribute to a better understanding of the human dimensions of global environmental change [51,52]. Coordination of research through IGBP and IHDP roughly followed the 'coordination by administrators' model [44]. That is, both programmes were supported by a Scientific Committee which acted as the main decision-making body and set out strategic directions. Further, both programmes consisted of multiple international Core Projects focusing on specific dimensions of global environmental change research, ranging from atmospheric chemistry (Integrated Global Atmospheric Chemistry project), to land-use change (Global Land Project), to urbanization (Urbanization and Global Environmental Change project).[4] An international secretariat coordinated the activities of the programme and facilitated information exchange and scientific collaboration.

IGBP and IHDP provide exemplary cases of coordination in global change and sustainability research. They are selected as case studies because they share sufficient characteristics to allow for meaningful comparison, while they also differ in their respective research domain, membership and development. IGBP and IHDP shared three core objectives: first, both programmes aimed to bring together researchers from *different disciplines* in a

[3] The other two global change programmes are the World Climate Research Programme (WCRP; 1980-present) and DIVERSITAS, a programme on biodiversity research (1991–2014). Between 2002 and 2012, the four programmes collaborated through the Earth System Science Partnership (ESSP), which aimed to contribute to further interdisciplinary integration in the study of global change.

[4] After the closure of IGBP and IHDP, most Core Projects have continued under the umbrella of the new research platform 'Future Earth: Research for Global Sustainability'.

Table 1

Overview of core objectives reviewed in this study

Objective	Disciplinary diversity	Geographical diversity	Conceptual integration
Definition	Bringing together knowledge from different disciplinary perspectives, including both natural and social sciences	Collaboration between researchers from different countries globally	Developing a shared conceptual language based on the integration of research from different perspectives
Operationalization	Disciplinary diversity of the knowledge base of core publications	Geographical diversity of authorship of core publications	Shared conceptual language across core publications
Data	References of core publication	Authors of core publications (country)	Abstracts of core publications
Indicator(s)	• Rao-stirling diversity • Overlay maps of science • Comparison to control set	• Shannon's diversity index • Authorship by OECD/non-OECD countries	• Co-word network • Network density

coordinated effort to address issues of global environmental change; second, both programmes aimed to enhance *international collaboration* among multiple countries and regions globally, with a particular emphasis on including researchers from the Global South; and, third, both programmes aimed to achieve *integration and synthesis* of research from various domains of research and multiple world regions [53,50•,54].

The remainder of this section reviews research coordination through IGBP and IHDP based on a scientometric analysis. Scientometric analysis is a quantitative approach to the study of science. Scientometric studies are based on meta-data of scientific publications (also called bibliometric data), such as journal of publication, research field, number of citations and author affiliation. The approach is widely employed to map, visualize and review developments and impacts of scientific research [55]. Scientometric analysis is employed in this study in order to review the development of research coordination over time by assessing the scientific output of these research programmes vis-à-vis their core objectives. Although an analysis of scientific publications does not account for all possible outcomes of science coordination, bibliometric data are widely regarded as revealing and accessible records of scientific output [56]. Bibliometric data are retrieved from the list of core publications provided in the annual reports of IGBP and IHDP. It is assumed that these self-selected core publications represent the main scientific output of the programmes. To be able to track developments over time, publications were retrieved for different periods over the course of operation of the two programmes. This resulted in a dataset of 398 scientific publications. The main focuses of the analysis are the three core objectives of global research programmes identified above: to bring together knowledge from *multiple disciplines*, to enhance *international collaboration*, and to contribute to *integration and synthesis* of research. The analysis combines multiple indicators in order to assess to what extent IGBP and IHDP managed to shape the composition of research undertaken under their umbrella (see Table 1 for an overview; more details in Appendix A in Supplementary material). Results are compared to a control set of publications that represent the research domains of these programmes. The results are interpreted by taking into account contextual developments and the (changing) mission of both programmes. Further details on the scientometric analysis are presented in Appendix A in Supplementary material.

Disciplinary diversity

One of the main aims of both IGBP and IHDP was to bring together and integrate research from different disciplinary domains. This objective is reviewed here based on the diversity of cited references in core publications. It is assumed that the inclusion of references from diverse disciplinary fields indicates an interdisciplinary approach. The diversity of cited references is a commonly used scientometric indicator for interdisciplinarity and reflects the breadth of knowledge on which scientific publications are based [57,58].

For IGBP, disciplinary diversity was low in its initial period of operation, when most cited references reflected a relatively narrow natural sciences research domain. However, disciplinary diversity increased substantially in the period thereafter, and then stabilized at a level similar to its respective research field (see Table 2 and Figure 1). This reflects the developments in research coordination by IGBP. In its initial period of operation, IGBP was largely community driven, with the programme supporting collaborations that emerged from the existing community of global change researchers [50•]. Towards the end of the 1990s, IGBP began to take a more active, steering role, with the explicit objective to increase the diversity of disciplines included in the programme, particularly towards the social sciences [59]. This is reflected in the development of the knowledge base, which includes a sizable share of literature from social science research domains such as geography, political science, development studies and ecological economics in the period 2002/3. Yet, disciplinary diversity decreased thereafter, as the focus of the knowledge base returned to natural sciences disciplines. This may be partly

Table 2

Indicators for disciplinary diversity, geographical diversity and conceptual integration of IGBP research

	1997/1998	2002/2003	2007/2008	2012/2013
Core publication				
Nr of publications	29	62	86	131
Nr of references	1014	2860	5489	8127
Disciplinary diversity				
Nr of journals	56	165	234	326
Rao-Stirling	0.083	0.132	0.102	0.106
Rao-Stirling (control)	0.094	0.093	0.102	0.103
Geographical diversity				
Number of countries	29	26	42	53
Shannon's H	2,92	2,66	3,15	3,17
Non-OECD countries	15 (52%)	7 (27%)	16 (38%)	23 (43%)
Non-OECD authorship	17 (21%)	10 (7%)	23 (10%)	57 (12%)
Conceptual integration				
Density	0,73	0,65	0,79	0,81

Note. Core publications were retrieved from annual reports of IGBP and meta-date was downloaded from Web of Science. Disciplinary diversity is based on the references of core publications. The Rao-Stirling diversity indicator was used to calculate the diversity of the cited references of core publication and control set. The Rao-Stirling measure provides an index between 0 and 1, with a higher value indicating a larger diversity of cited references (see also Figure 1). Geographical diversity is based the country of authors of core publications. Shannon's H provides a measure of diversity taking into account number of countries and balance between them, with a higher value representing a higher diversity. In addition, the number of countries and authorships from outside the OECD was calculated. Conceptual integration is based on the density of the co-word maps of abstract words (see Figure 3).

explained by the growth of IHDP and development of the interdisciplinary Earth System Science Partnership, which made inclusion of the social sciences less of a priority of IGBP. At the same time, this indicates that the expected diversification through partnership with these programmes did not materialize.

For IHDP, the diversity of the knowledge base steadily increased over the studied period, including a larger and more diverse set of publications from both the natural and social sciences for each subsequent period (Table 3 and Figure 2). IHDP was established with the aim to strengthen the social science perspective in the traditionally more natural sciences oriented domain of global environmental change research [54]. This position between the natural and social sciences is reflected in the relatively diverse knowledge base of IHDP, which shows a balance of references from the natural and social sciences. However, the diversity of IHDP's knowledge base is lower than its respective research field (i.e. the journals IHDP core publications are most frequently published in), raising the question to what extent disciplinary diversity of IHDP can be attributed to coordination or reflects broader developments in research on the human dimensions of global change.

Geographical diversity

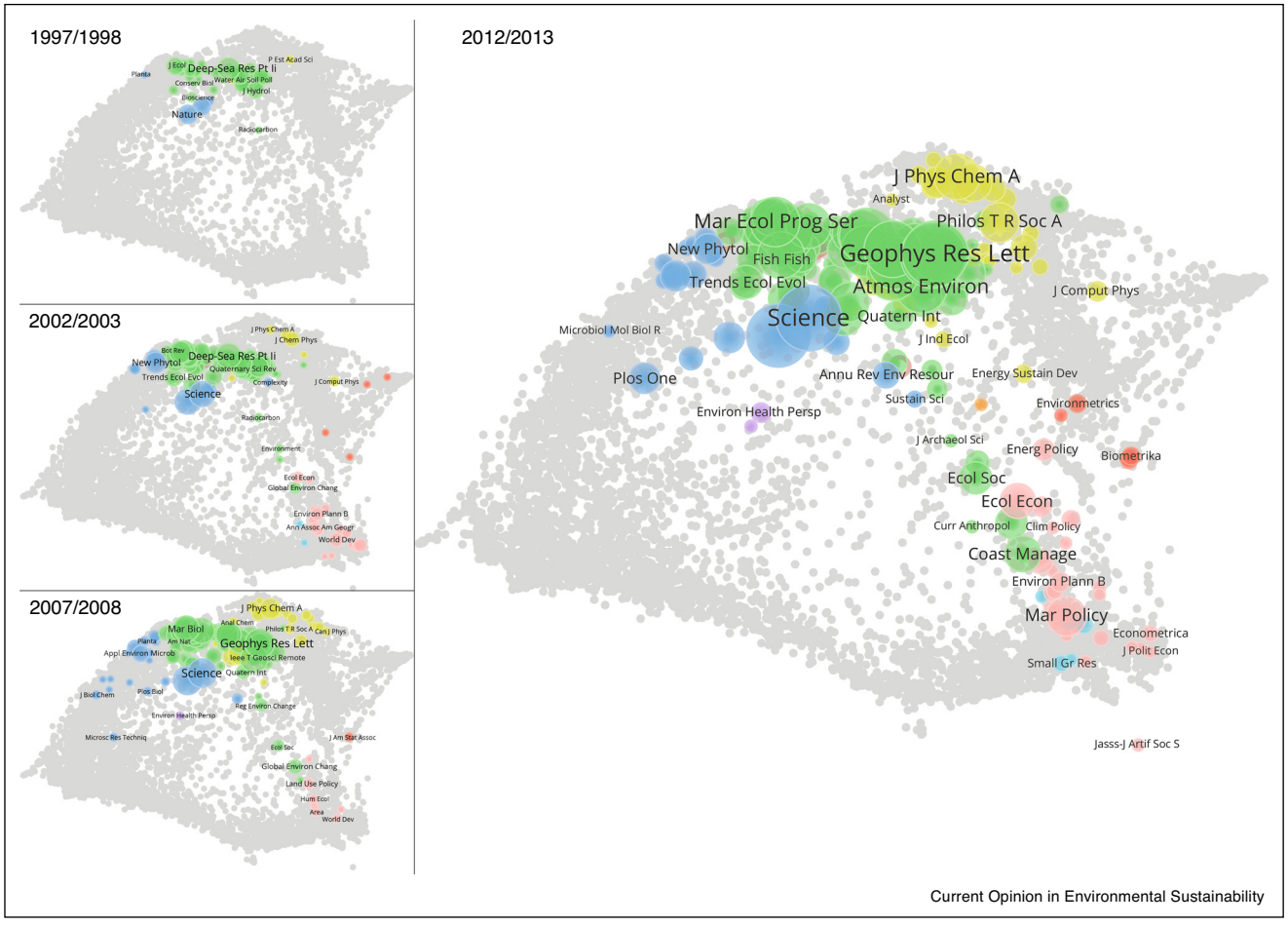
A second core objective of both IGBP and IHDP was to stimulate international collaboration, with a particular emphasis on supporting participation of researchers from the Global South. Geographical diversity is here reviewed based on the authorship of core publication, taking into account the country of residence of these authors, the distribution of authorship across countries and the balance between authors from OECD and non-OECD countries.

For both IGBP and IHDP, geographical diversity increased over time, yet participation of non-OECD countries, particularly in relative terms of authorship, remained behind (see Tables 2 and 3). For IGBP, geographical diversity is noticeably low in the period 2002/3. This coincides with the substantial diversification of IGBP's knowledge base in the same period, raising the question whether the focus for this period on steering IGBP towards a more diverse and interdisciplinary community limited efforts to enhance geographical diversity. For IHDP, an external review of the programme in 2006 noted the 'disproportionate participation of scientists from developed countries in IHDP scientific activities', urging IHDP to direct strategic effort to enhance 'the capacity of researchers in the South to shape and direct global change research through their participation as equal and active partners' [51]. In terms of authorship of core publications, these strategies proved of limited success.

Conceptual integration

Finally, both programmes shared the objective to integrate research from multiple disciplines and world regions and develop a common conceptual language. A co-word network that maps the connection between frequently used terms and concepts in the abstracts of core publications provides insights in the conceptual development of research programmes over time. A higher density of the

Figure 1



References of IGBP core publications projected on global journal map.
Projection of IGBP references on a global map of scientific journals. Areas on the map represent different (disciplinary) domains of science [65,66]. The overlay maps were produced using VOSviewer. The colors represent clusters of journals. Broadly speaking, the green cluster contains journals concerned with environmental sciences, including geosciences and ecology; yellow contains chemistry and physics; blue contains multi-disciplinary journals such as Science and Nature; pink contains management, economics, and policy-oriented journals. The size of the circles reflects the number of references.

co-word network indicating a more coherent research output, although it is important to note that integration presumes diversity of the knowledge base ([60]; see Appendix A in Supplementary material for more detail).

Over the course of their operation, the coherence of research output increased for both IGBP (see Table 2 and Figure 3) and IHDP (see Table 3 and Figure 4), suggesting that both programmes managed to work towards a common language. From its early operating phase, IGBP advanced the notion of the Earth System as a conceptual framework for studying the combined physical, chemical, and biological aspects of the planet [61]. This is reflected in the relatively high conceptual integration. Nevertheless, the diversification of the knowledge base during the period 2002/2003 period coincided with a less coherent research output. This is recognized in a major synthesis of IGBP's work published in 2004, which applauds the success of IGBP in bringing together multiple disciplinary perspectives on global environmental change, yet also points out that IGBP's coordinated research effort 'falls short [. . .] of reaching the level of integration required to understand the dynamics of the Earth System in a holistic way' [59]. Over the subsequent years integration increased, while this period also saw a decrease in disciplinary diversity. For IHDP, conceptual integration was relatively low in its initial period of operation, which reflects the structure of individual Core Projects that operated relatively independently. With its 2007 Strategic Plan, IHDP turned its attention explicitly towards integration of social science research on global change [54]. This resulted in several synthesis and review publications on cross-cutting research themes (e.g. Ref. [62]), and is reflected in the semantic maps (Figure 4) which indicate

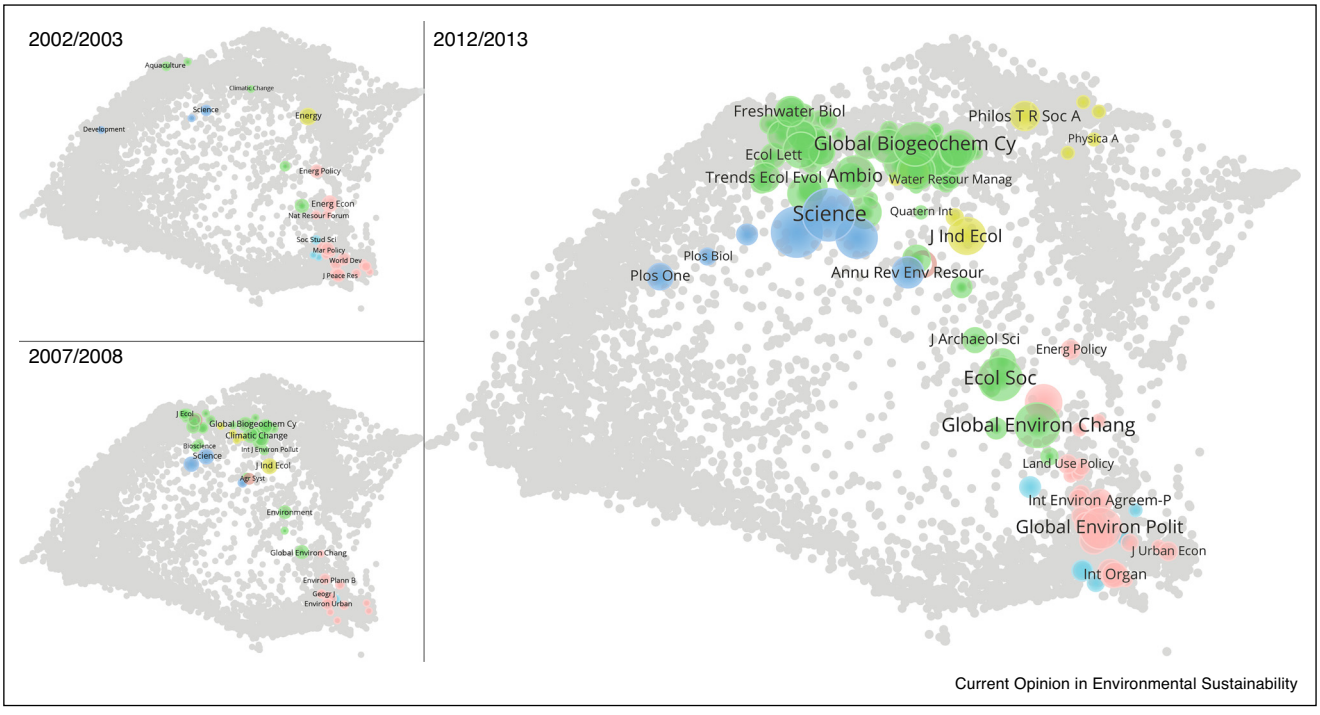
Table 3

Indicators for disciplinary diversity, geographical diversity and conceptual integration of IHDP research

	2002/2003	2007/2008	2012/2013
Core publication			
Nr of publications	23	22	45
Nr of references	731	881	2407
Disciplinary diversity			
Nr of journals	38	68	157
Rao-Stirling	0.173	0.186	0.191
Rao-Stirling (control)	0.225	0.215	0.222
Geographical diversity			
Number of countries	8	16	32
Shannon's H	1,59	2,45	2,96
Non-OECD countries	2 (25%)	7 (44%)	10 (31%)
Non-OECD authorship	2 (7%)	8 (24%)	17 (10%)
Conceptual integration			
Density	0,59	0,75	0,80

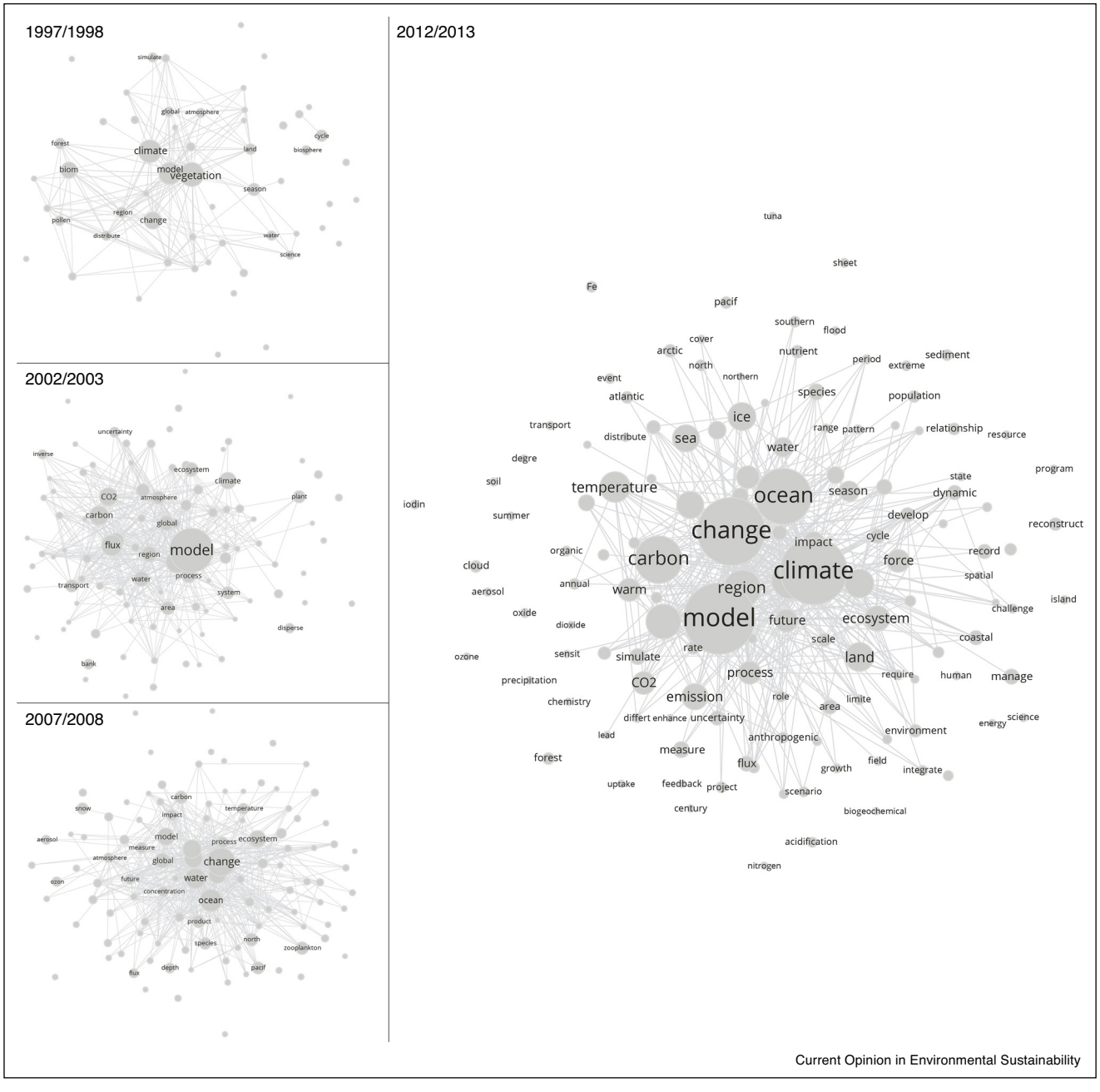
Note. Core publications were retrieved from annual reports of IHDP and meta-date was downloaded from Web of Science. The Rao-Stirling diversity indicator was used to calculate the diversity of the cited references of core publication and control set. The Rao-Stirling measure provides an index between 0 and 1, with a higher value indicating a larger diversity of cited references (see also Figure 2). Geographical diversity is based the country of authors of core publications. Shannon's H provides a measure of diversity taking into account number of countries and balance between them, with a higher value representing a higher diversity. In addition, the number of countries and authorships from outside the OECD was calculated. Conceptual integration is based on the density of the co-word maps of abstract words (see Figure 4).

Figure 2



References of IHDP core publications projected on global journal map.
Projection of IHDP references on a global map of scientific journals. Areas on the map represent different (disciplinary) domains of science [65,66]. The overlay maps were produced using VOSviewer. Colors represent clusters of journals. Broadly speaking, the green cluster contains journals concerned with environmental sciences, including geosciences and ecology; yellow contains chemistry and physics; blue contains multi-disciplinary journals such as Science and Nature; pink contains management, economics, and policy-oriented journals. The size of the circles reflects the number of references.

Figure 3



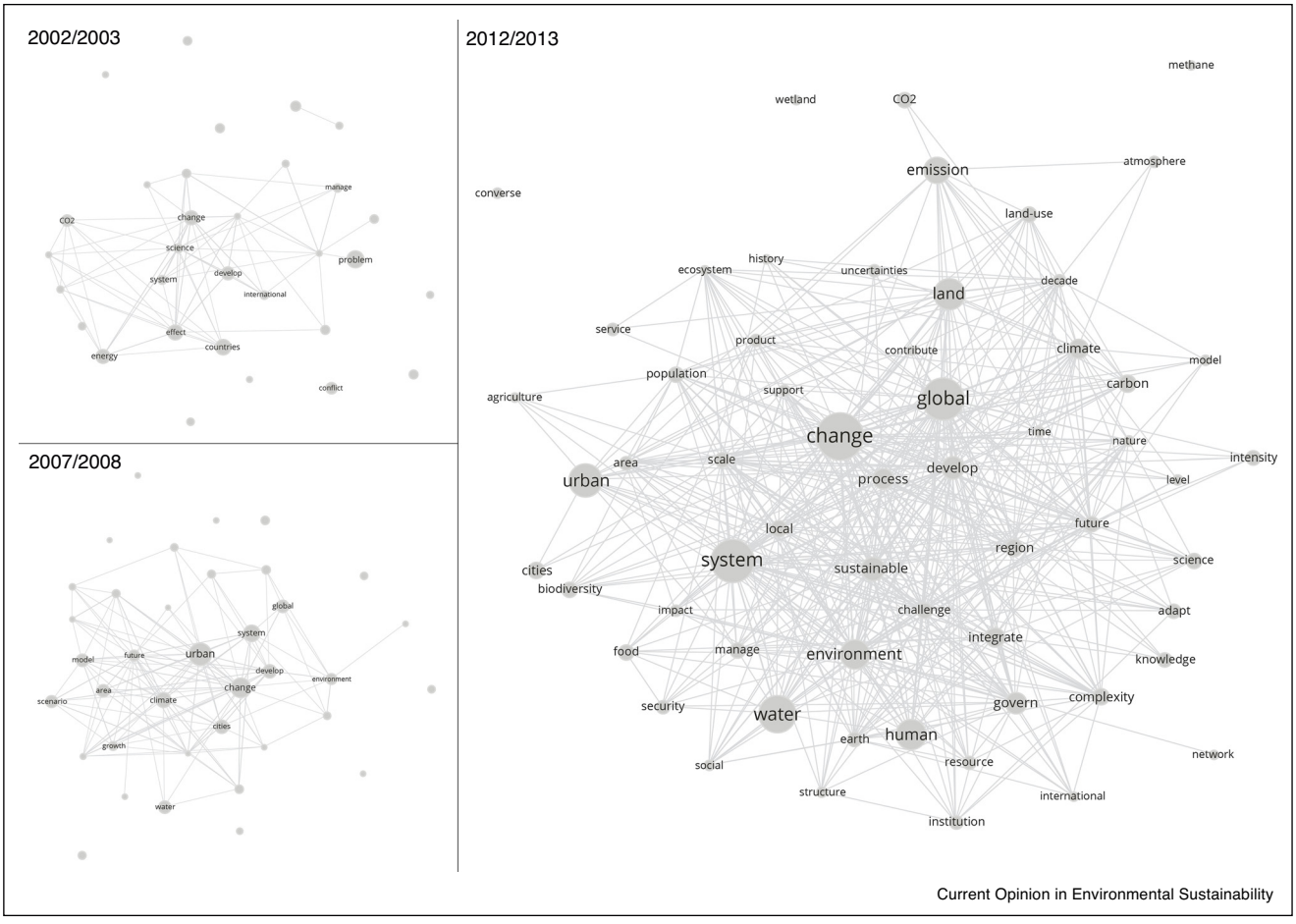
Co-word maps of abstract words of IGBP core publications.
Semantic mapping of abstracts based on the 5% most frequently used words. The software programme UCINET 6 for Windows was used to compute the networks and VOS Viewer was used to produce the visualizations. Lines connect word pairs that occur in the same abstract. Size of the circles represents frequency of occurrence.

that IHDP developed an increasingly integrated research portfolio over the studied period.

Discussion of scientometric review

This scientometric analysis of two major research programmes in global environmental change research explored whether research coordination has been conducive to disciplinary diversity, international collaboration, and the integration and synthesis of research. The results paint a mixed picture. Both programmes managed to develop a shared conceptual language over the studied period. Yet, diversification of the knowledge base

Figure 4



Co-word maps of abstract words of IHDP core publications.
Semantic mapping of abstracts based on the 5% most frequently used words. The software programme UCINET 6 for Windows was used to compute the networks and VOSviewer was used to produce the visualizations. Lines connect word pairs that occur in the same abstract. Size of the circles represents frequency of occurrence.

occurred only with limited success, and in most cases reflected broader developments in the research field. This raises the question whether the observed diversification can be attributed to research coordination. Moreover, regardless of the repeatedly stated intention to build a global research programme, participation of non-OECD authors remained limited in both programmes.

There are some notable limitations to the insights that a scientometric analysis can provide on research coordination. First, this scientometric analysis focused exclusively on the influence of science coordination on scientific knowledge production. Other important functions of science coordination mechanisms, such as communication of science to a non-academic audience or facilitation of collaboration between scientists and non-scientists, where not included in the analysis. Second, the question remains to what extent developments in scientific output can be attributed to steering by science coordination mechanism or are the results of external developments. This study included a control set in order to account for the differences in development of the research programme and the broader research field. Nevertheless, it is important to remain careful when making causal claims. Future work could overcome some of these limitations by including more indicators to increase the sensitivity of the analysis, and by complementing scientometric insights with qualitative methods such as interviews.

Summary and outlook

This paper has critically reflected on the assumption that global coordination improves the performance of global change and sustainability research. The review of the literature pointed out that global research programmes and networks, also without a large funding base, can be seen as coordination mechanisms that have the potential

to shape research collaboration. Yet, knowledge on their actual outcomes and effects remains limited. The scientometric analysis of IGBP and IHDP built on and complemented these insights, and revealed that while science coordination contributed to interdisciplinary collaboration and conceptual integration, the objective of global collaboration was met with limited success. While IGBP and IHDP are now closed, coordination of global change and sustainability research continues under the new global research platform 'Future Earth: research for global sustainability' [12,19]. Based on the dual review in this paper, I highlight some important aspects of global science coordination that warrant further reflection.

First, science coordination often aims to support multiple objectives which are not necessarily aligned. Prioritizing a specific objective might, unwillingly and unintentionally, divert interest and resources from other functions of science coordination. This is reflected in the case of IGBP, where the focus on interdisciplinary collaboration and integration, appeared to come at the expense of international inclusiveness. Thus, careful reflection on potentials for conflict and synergies among the multiple objectives of science coordination is required. Second, the presence of a shared research approach can be both a blessing and a curse, as it shapes the contribution of research programmes and networks but might also constrain the involvement of research with disciplinary perspectives or geographical backgrounds not aligned with this shared approach. Related to this, there appears to be a tension between the importance of a strong and committed core community and the ability to attract and open up to new members and approaches. Finally, third, it is important to consider who participates in and shapes global research programmes [63,64]. Interdisciplinary and global inclusiveness are core objectives of science coordination mechanisms concerned with the future of our planet, yet particularly the later has only been addressed with limited success. At the same time, coordination mechanisms have the potential to make important conceptual contributions and shape the direction of a research domain. To support a meaningful contribution by global research programmes and networks, repeated effort is required to ensure that such coordination builds on balanced and inclusive participation.

Given the large amount of energy and resources directed at science coordination today, the increasing prominence of science coordination mechanisms in multiple domains of research, and the need for greater collaboration across disciplinary and geographical boundaries, the benefits as well as limitations of global science coordination deserve to receive more careful scrutiny. Further in-depth study should provide insights into which coordination strategies work and which don't, under which conditions, and in which context.

Conflict of interest statement

Nothing declared.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.cosust.2019.07.006.

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- • of special interest
- •• of outstanding interest

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