



INTER-AMERICAN INSTITUTE FOR GLOBAL CHANGE RESEARCH

The evolution of interdisciplinarity over 20 years of global change research by the IAI

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Abstract

Global change is pervasive, cutting across human and natural systems. Global change research aiming to comprehend the feedbacks within and across social and ecological systems, and to inform decision making must therefore integrate across social and natural sciences. Through questionnaires and interviews with former and current recipients of grants and the analysis of institutional documents, we show that the promotion of interdisciplinarity requires more than changing the requirements of funding calls. Successes have relied on leveraging and linking the motivations of natural and social scientists with the needs and motivations of practitioners and policy makers. The motivations for an integration between disciplines have been developed by (1) providing space for experiential learning by researchers, (2) facilitating networking and teamwork across disciplines, (3) exposing researchers to new concepts or tools that support interdisciplinarity, (4) maintaining persistent mentorship and support for cultivating cross-disciplinary thinking, and (5) connecting research to tangible problems. This paper describes the cumulative experience of 20 years of motivating and monitoring interdisciplinary research, providing an environment for learning across disciplines, and structuring research programs to advance knowledge to inform decision making on responses to global change.

1. Introduction

Global change research must be interdisciplinary to address the pervasiveness and cross-cutting nature of global change and account for its effects on inseparable social-ecological systems [1–3]. The Inter-American Institute for Global Change Research (IAI) was created in 1992 to provide research capacity in the Americas for conducting research and develop the region's capacity to address challenges of global change. As such, a major component of its mandate is the promotion of an interdisciplinary approach.

Achieving interdisciplinarity in global change research requires breaking deeply engrained disciplinary barriers [2,4]. In the operating context of the IAI – and others [3,5] – breaking these barriers has required a strategic and deliberate process of building upon and augmenting the motivations of researchers to participate in interdisciplinary projects. This process has involved modifying Requests for Proposals and providing funding mechanisms to incentivise interdisciplinary pursuits. However, the experience of the IAI has shown that modifying the conditions of calls for proposals is not enough to achieve true interdisciplinary, and that researchers have to be motivated. Such motivations are necessary to overcome the current academic incentive structure, which promotes individual, discipline-based work over teamwork [6]. The IAI's strategies have drawn on the desire of researchers to learn from different disciplines, tackle tangible and applied problems, and garner recognition within the international global change science community.

The purpose of this paper is to provide an overview of the evolutionary process of achieving interdisciplinarity based on the IAI's more than 20 years of experience and with a focus on some of its major funding programs (Figure 1 – the Collaborative Research Networks [CRN] 1-3 and the Small Grants Program on the Human Dimensions [SGP-HD]). We used a variety of methods to construct a meta-narrative regarding the evolution of interdisciplinarity in the IAI's funding program. This approach leverages the expertise of the IAI and synthesizes current opinion in the literature, but also provides researchers engaged in IAI-funded projects with the opportunity to have a voice. These methods included surveys, semi-structured interviews and document analysis.

The paper discusses the importance and influence of the IAI's strategies for motivating researchers towards interdisciplinarity by first demonstrating how interdisciplinarity has evolved over the course of the IAI's funding programs, characterizing the enablers and constraints on interdisciplinarity, and synthesizing the IAI's lessons learned for promoting interdisciplinarity. It then discusses the broader implications and transferability of these lessons.

2. Methods

Survey

Surveys are structured questionnaires aiming to elicit qualitative and quantitative information from a target population or sample [7]. We used surveys to measure interdisciplinarity at different stages of the research process and across different research programs funded by the IAI. Questions concerned discipline integration, researcher motivation and the value of interdisciplinary research.

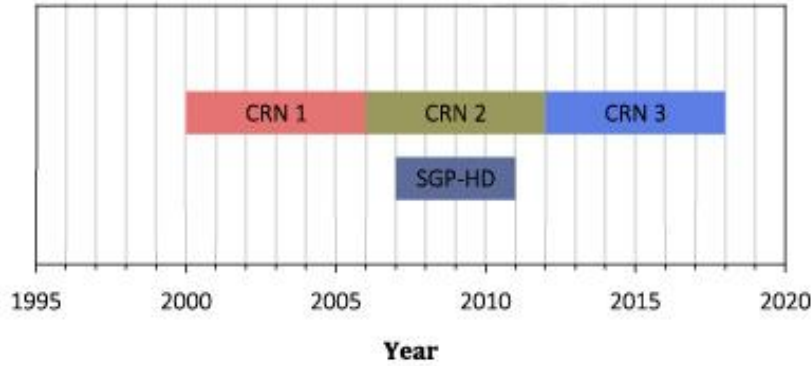


Figure 1. Timeline of selected funding programs.

Surveys were administered online using Google Forms and respondents were contacted via email. An initial email was sent to respondents explaining the project and providing a link to the survey. Respondents were given two weeks to respond to the survey. Two reminders were sent, the first one week after initial contact and the second on the morning of the response deadline. The survey was administered in early December 2014.

The target population for the survey was all researchers engaged in projects funded under CRN 2, CRN 3 and the SGP-HD according to the IAI's databases (n=338). These programs represent 10 years of science funding activities by the IAI. Several of the respondents had also been involved in CRN 1, which was funded in 1999. The survey was sent to a subset of the target population (n=279) due to incomplete, invalid or unavailable contact information.

In total, there were 76 responses to the survey for a response rate of 28%, which is low but consistent with online surveys [8]. Possible reasons for low response rates include (1) timing in December, (2) failed contact (i.e., email addresses out of date or emails filtered into junk mail), and (3) limitations associated with Google Forms (e.g., respondents could not save and return to responses). Nevertheless, a very good coverage of funded programs was achieved (Table 1).

Table 1. Coverage of projects in the survey sample.

Program	Projects	Projects covered in sample ¹
	(n)	(n)
CRN 1	14	8
CRN 2	13	12
SGP-HD	7	6
CRN 3	10	10

¹Projects having at least one respondent in the sample.

Semi-structured interviews

Semi-structured interviews are an approach to qualitative data gathering using open-ended questions, with the goal being to have nearly free-flowing interviews that mimic natural conversation [9]. We used semi-structured interviews to obtain in-depth data regarding (1) the evolution of interdisciplinarity, (2) the motivations of researchers engaged in interdisciplinary research, (3) the benefits and challenges associated with conducting interdisciplinary research, and (4) the lessons learned from researchers' experience. In total, 23 semi-structured interviews were conducted with researchers from throughout

the Americas and with backgrounds spanning the natural and social sciences; 21 of them were done remotely and 2 in person. Interviews lasted between 20 and 60 minutes and were recorded. The data were analyzed using a meta-matrix approach [9]. The matrix consisted of rows for each interview and columns representing the themes noted above. Each cell in the matrix contained a summary of the information presented in each interview according to the themes. Findings from each theme were then synthesized according to information across all interviews.

Document analysis

Document analysis is a systematic and focused review of relevant written materials [10], which in this case included the IAI's proposal and researcher databases. These documents provided evidence of collaboration between countries and research institutions. Documents were coded for collaboration by project and then analyzed using network analysis and linked to a Geographic Information System (GIS) by georeferencing nodes. The coding was completed using Microsoft Excel, the network analysis and visualization took place in Gephi, and ESRI's ArcMAP was used for mapping and spatial analysis.

3. The evolution of interdisciplinary research funded by the IAI

The research yielded an in-depth description of interdisciplinary evolution with the IAI's programs. Initially, despite the IAI's more comprehensive mandate and consistent with the field in general [4], global change research was mostly focused on natural sciences with social sciences lagging far behind. It was thought that the role of science to confront global change was largely to provide knowledge of biophysical systems and processes that could later be applied in policy and practice. As a result, interdisciplinary research was largely limited to collaborations within the natural sciences. The natural science focus overlooked the interconnections and feedbacks between natural and social systems. In addition, little attention was given to how the knowledge generated might move from the research community to the practitioner or policy-maker community [11,12], or how it might be shaped by that user community.

With the recognition that research of global change inherently involves natural and human disciplines, and with changing demands on science outcomes, the IAI was tasked with operationalizing interdisciplinary research. Through its efforts there has been a clearly greater integration of social sciences into project conceptualization and methodologies (Figure 2). For instance, only 33% of survey respondents reported social science participation in project conceptual stages under CRN 1. This number almost doubles to 63% under CRN 2 and continues to grow to 87% under CRN 3. Additionally, qualitative methodologies are increasingly used with only 50% of respondents reporting the use of qualitative methods in CRN 1 which rises to 91% under CRN 3. A similar evolution and increased integration between natural and social sciences was observed by Mooney et al. [4] when examining global change research more broadly. However, also similar to Mooney et al.'s [4] observations it is likely that more integration is required in the IAI's programs.

Despite the increased inclusion of social sciences, IAI programs remain dominated by natural scientists, mostly ecologists (Figure 3). The dominant discipline based on word frequencies of researchers' self-identified disciplinary backgrounds and expertise in proposals has been ecology in both CRN 2 and 3¹. However, disciplines containing the word 'social' were more prevalent in CRN 3 than CRN 2, which supports the findings discussed above. Also, although many researchers identify with ecology as their

¹ Note: There was not enough documentation to conduct similar analysis for CRN 1.

main expertise they may in fact be conducting interdisciplinary research or be comfortable in interdisciplinary teams: 78% of survey respondents reported changing the way they do research because of their engagement on interdisciplinary projects. Many ecologists involved in IAI programs are now operating in an interdisciplinary environment and have embraced some elements of interdisciplinarity in their own research programs. Broto et al. [13] has theorized that the type of disciplinary grounding exhibited by these ecologists is common when engaging in interdisciplinary research.

Part of what has helped researchers make these transitions towards interdisciplinarity has been engagement in collaborative, international teams and networks. Involvement in these networks over time helps build the trust needed between researchers and/or research organizations to pursue interdisciplinary teamwork [14]. The IAI has stimulated networks of collaboration between organizations engaged in research (e.g., universities, government bodies, non-governmental organizations – Figure 4). A significant component of this network has been the development of South-South research collaboration. The proportion of South-South collaborations increased from 52% in CRN 2 to 68% under CRN 3². This change indicates an improving interest and capacity for interdisciplinary research within the South.

4. Enablers and constraints

The challenges and benefits associated with conducting interdisciplinary research influence the willingness of researchers to engage. Researchers funded by the IAI for interdisciplinary projects have been confronted by numerous challenges but have also perceived many benefits of enduring in the face of adversity. Among the most reported challenges are difficulties integrating results across natural and social sciences and also finding compatible methods. These are similar to challenges reported elsewhere [15]. Pahl-Wostl et al. [6] have proposed that creating innovative, interdisciplinary methods has been a major stumbling block for global change research.

Additionally, IAI-funded researchers have been challenged to frame interdisciplinary research problems and produce research frameworks flexible enough to accommodate wide interdisciplinarity. Joint framing of research problems has been called for in the literature (e.g., [16]) and has had demonstrated benefits (e.g., [17,18]), but it can take significant time to accomplish. Also problematic has been misunderstanding by natural scientists of what social science is and what it can deliver.

Researchers also noted numerous benefits from interdisciplinary research. Among the most reported benefits are the improved applicability to policy, social relevance, and community reception of interdisciplinary research. Researchers perceived benefits related to the scientific appeal of interdisciplinary research. Learning across disciplines amongst members of the research team was also frequently noted as a benefit from interdisciplinary research.

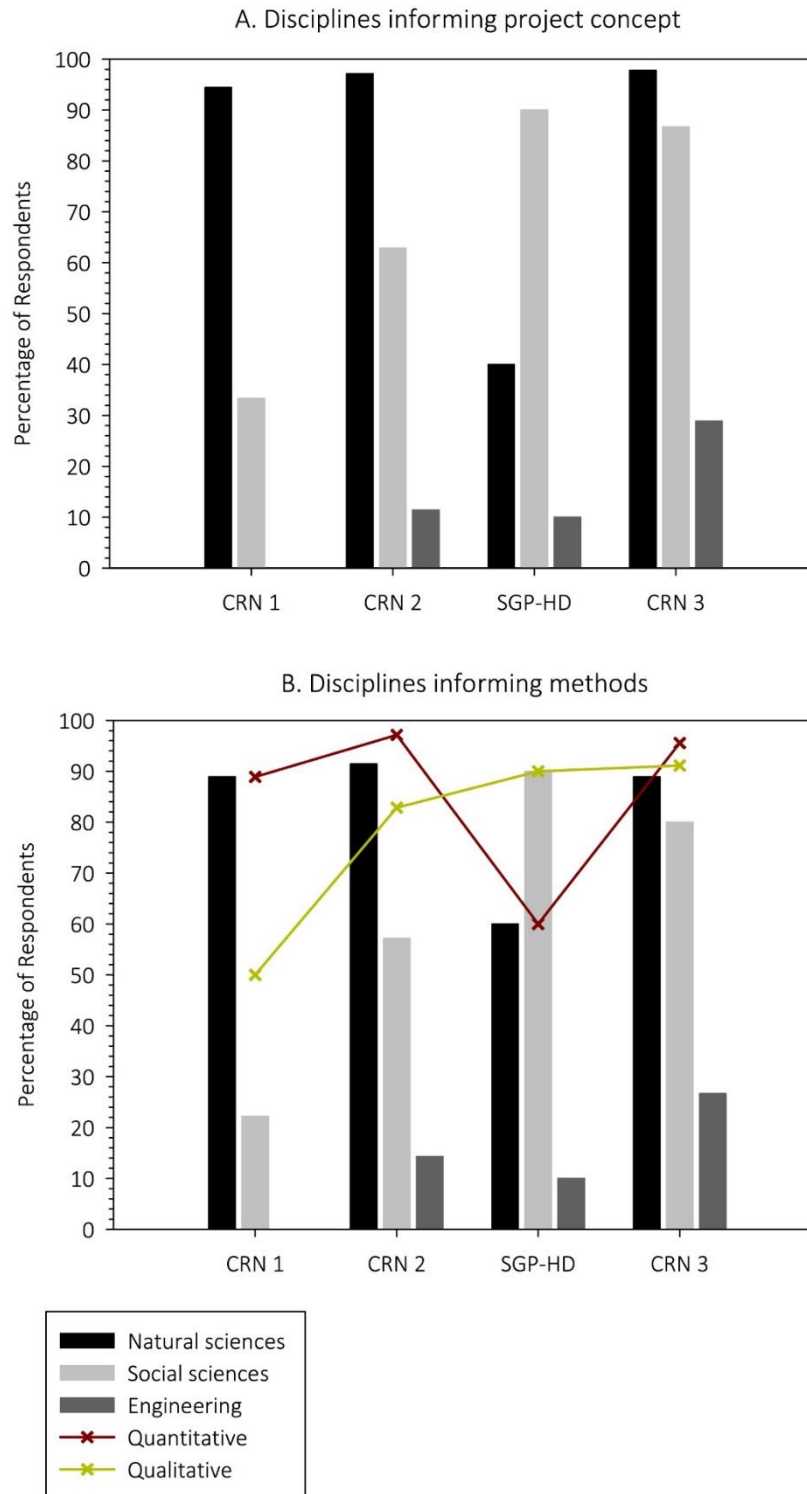
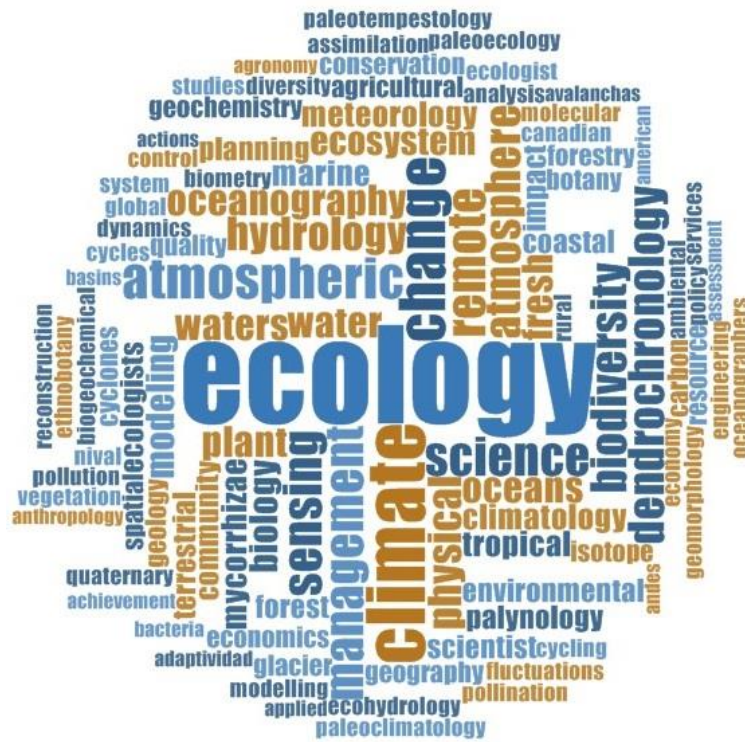


Figure 2. Discipline integration in project concepts and methodologies across IAI programs.

Note: The SGP-HD call was directed towards social scientists; therefore the greater integration of social sciences within SGP-HD than CRN 3 is expected.

A. Expertise of researchers, CRN 2

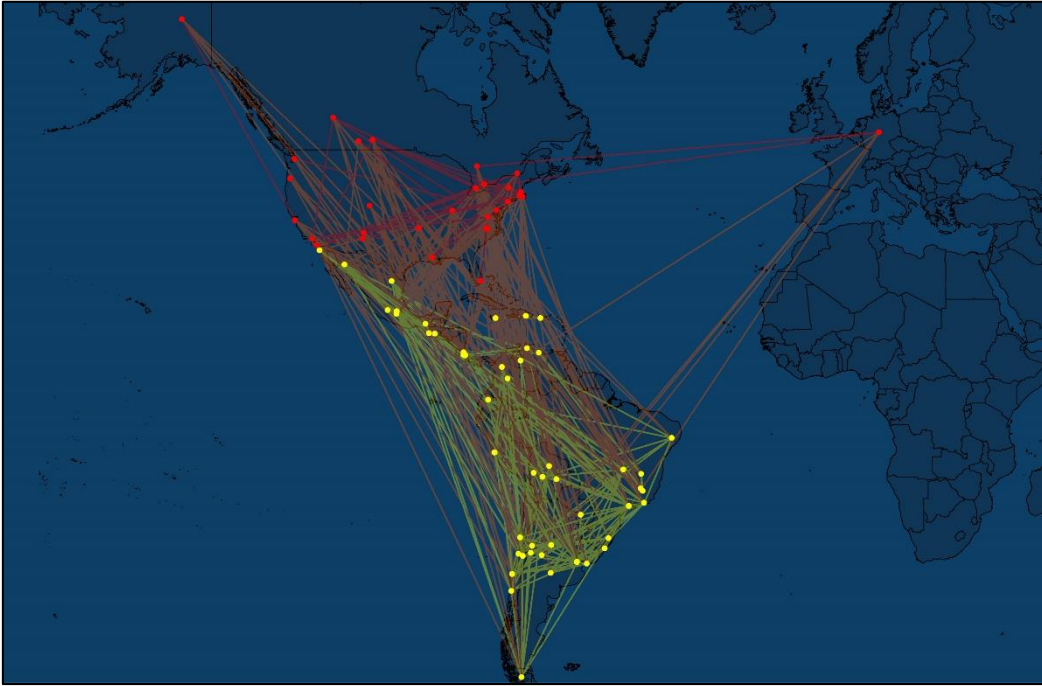


B. Expertise of researchers, CRN 3



Figure 3. Word frequencies of researchers engaged in CRN 2 and 3

A. Organizational collaboration, CRN 2



B. Organizational collaboration, CRN 3

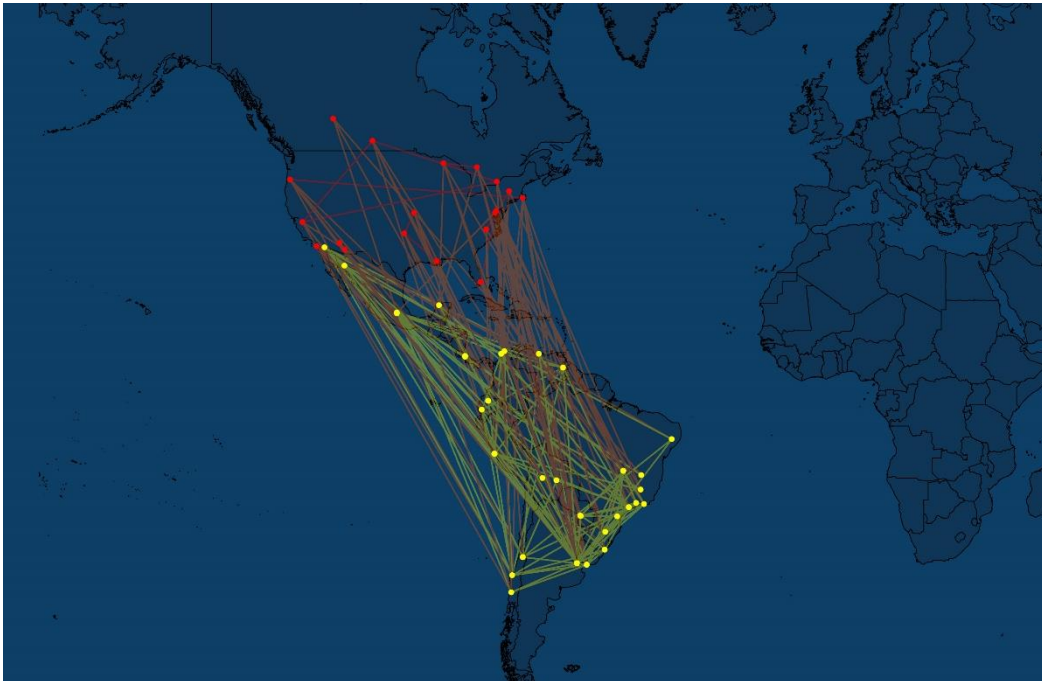


Figure 4. CRN 2 and 3 collaboration between research organizations.

Red points are organizations in the Global North and yellow are in the Global South. Red lines indicate collaboration between organizations in the Global North (i.e., North-North collaboration), yellow lines between organizations in the Global South (i.e., South-South collaboration), and orange lines between organizations in the Global North and South (i.e., North-South collaboration)

5. Lessons learned

Both surveys and interviews show the importance of researchers' motivation for the evolving approaches to interdisciplinary science. The successes of the programs have relied upon the IAI's ability to motivate researchers to overcome constraints by facilitating their awareness and experiences of the benefits. The IAI has actively sought to improve these motivations by (1) providing space for experiential learning by researchers, (2) facilitating networking and teamwork across disciplines, (3) exposing researchers to new concepts or tools that support interdisciplinarity, (4) maintaining persistent mentorship and support for cultivating cross-disciplinary thinking, and (5) connecting research to tangible problems.

Providing space for experiential learning by researchers

Approximately 56% of researchers engaged in CRN 2, 70% in SGP-HD, and 80% in CRN 3 noted learning as a major motivating factor for interdisciplinary pursuits. The IAI, by requiring and nurturing interdisciplinary teams, contributes to the ability of researchers to learn from other disciplines. The projects demonstrate, at times by trial and error, how to do interdisciplinary research. Many researchers in the interviews noted how their experience on IAI funded projects had allowed them to learn the intricacies of conducting interdisciplinary research and to discover the value of findings from different disciplines. Also important to facilitate cross-disciplinary learning is the trust that is fostered between researchers through engagement in shared learning experiences [14]. Many also noted how this learning and desire for continued learning helped maintain interdisciplinarity within their ongoing research programs.

Exposing researchers to new concepts or tools that support interdisciplinarity

Moving beyond disciplinaryity requires updating the concepts or tools used by researchers [19]. For instance, the IAI hosts a number of training programs on different interdisciplinary modeling techniques and the use of integrative concepts (e.g., climate change vulnerability). Boundary concepts, described by Mattor et al. ([20]:95) as “fuzzy terms or phrases that refer to the same object, process, or quality in the construction of shared understanding of a given phenomenon”, are gaining use within IAI-funded research. Boundary concepts are thought to be an effective tool for cross-disciplinary integration, although it can take significant time for them to yield benefits [20]. Similar experience is being observed within the IAI, where two boundary objects in particular – ecosystem services (sensu [21]) and social-ecological systems (sensu [22]) – have proven valuable despite requiring time to operationalize. The challenges lie in finding commonality when words or concepts are used quite differently by different researchers and within different disciplines [23]. Nonetheless, exposure of IAI researchers to new tools and concepts has leveraged their desire to learn and facilitated their entrance into, and continuance with interdisciplinary research.

Facilitating networking and teamwork across disciplines

The IAI has attempted to induce interdisciplinary networks through strategic interventions within its funding programs. For instance, the SGP-HD funding program was designed to foster greater collaborations between natural and social sciences through a special call for proposals that had a social science focus but also needed endorsement from natural science teams. This SGP-HD was conceived and launched in response to limited social science integration with the CRN 2 program. Projects under SGP-HD were required to partner and engage with just starting CRN 2 projects tackling similar or compatible research problems. Although conceived as a remedial action, the program was successful, with 70% of

SGP-HD and 60% of participating CRN 2 researchers noting their ability to establish relationships across disciplines as a result of the program.

However, during interviews and surveys, many researchers noted significant challenges in integrating two projects. The main reason was the fact that the projects funded under CRN 2 and those under SGP-HD were developed separately. The key lesson from the SGP-HD experiment was the need to foster cross-disciplinary networks and interactions before and during project conceptualization and proposal development. The interviews and surveys suggest that this insight was used in the subsequent CRN 3 program. Several researchers noted that their experience under SGP-HD prompted them to apply for CRN 3 funding and to establish interdisciplinary relationships early in the development of their successful CRN 3 proposals.

Maintaining persistent mentorship and support for cultivating cross-disciplinary thinking
An additional strategy of the IAI has been to provide support and mentorship for cultivating cross-disciplinary thinking. The IAI works with researchers who have developed proposals with potential to advance and assists in further developing the cross-disciplinary elements of these proposals. In this regard, the IAI provides researchers the opportunity and support to expand interdisciplinarity within proposed projects. Such support systems to advance interdisciplinarity have been called for in the literature (e.g., [24]), and the IAI's positive experience corroborates these calls.

Connecting research to tangible problems

Many researchers studying problems of global change hope to have practical and useful outcomes [5,18]. Approximately 90% of researchers engaged in CRN 2, SGP-HD, and CRN 3 noted the importance of having applied outcomes as a motivating factor for conducting interdisciplinary research. The IAI helps build and leverage this motivation by (1) funding projects that engage or even include practitioners and policy makers and (2) supporting researchers through capacity building for science communication and policy connection. Many IAI-funded projects and training events include participation of individuals from outside the academic community. This approach helps facilitate interactions between individuals operating in both the research and applied domains and stimulates cross-fertilization of ideas regarding the goals of interdisciplinary projects and feasible ways of operationalizing findings. Additionally, the IAI has a section of its organization aimed specifically at capacity building, research communication and policy integration, which supports researchers in building often needed skills in these areas [25]. Staff within this section work closely with researchers to improve their ability to tackle concrete problems and connect with actors in the applied domain. These strategies have helped the IAI motivate researchers towards adopting an interdisciplinary approach and move towards what Mauser et al. [24] call knowledge co-creation to tackle the real-world problems associated with global change. The significant strides made towards applied global change research as a result of IAI's funding programs warrant attention.

6. Discussion and conclusions

This paper demonstrates the approach of the IAI that has helped facilitate the evolution of global change research in the Americas from a mostly disciplinary endeavour to an interdisciplinary pursuit. But what are the broader implications of this approach? The first broader implication is that researchers, despite having good intentions, need help making the transition to interdisciplinary scholarship. Trying to induce interdisciplinary scholarship without due care and attention to capacity building is likely to fail.

Moving from disciplinary to interdisciplinary research is a learning process, and this process must be recognized and facilitated by relevant organizations and within funding mechanisms [24,26].

The second broader implication is the need for a multifaceted or bundled approach to addressing pre-existing structural constraints on interdisciplinary science (e.g., incentives for disciplinary and individually conducted research [6]). The success of the IAI's approach has not hinged on any single strategy, but success rather results from all the different strategies coming together to motivate researchers to pursue interdisciplinarity in the face of ongoing challenges. The IAI has contributed significantly to advancing both interdisciplinary and facilitating transdisciplinary or co-creation oriented research. These advances are demonstrated by the reports of researchers engaged in IAI-funded research, which suggest natural-social science integration has progressed and projects are aimed at practical outcomes.

There is an additional question worth exploring: are the lessons learned by the IAI transferable to similar organizations or other regions? This question is especially salient given the introduction and operationalization of the *Future Earth* funding program. Within the Americas, certainly *Future Earth* could learn from the IAI, especially since the two have synergistic goals. In other regions, it is likely that similar principles could be applied, such as the advancement of a bundled approach to motivating interdisciplinarity. However, care and attention should be given to translating and applying the principles in alternative cultural contexts.

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