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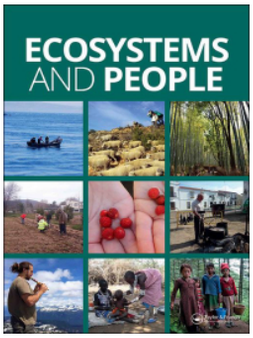

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RESEARCH

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Engaging at the science-policy interface as an early-career researcher: experiences and perceptions in biodiversity and ecosystem services research

Anna Filyushkina [a,*], Hyeonju Ryu [b,*], Andrew N. Kadykalo [c,*], Ranjini Murali [d], C. Sylvie Campagne [e,f], Carla-Leanne Washbourne [g], Sophie Peter [h], Nada Saidi [i], Thuan Sarzynski [j], Paola Fontanella Pisa [k,l], Giovanni Ávila-Flores [m] and Taha Amiar [n]

[a]Institute for Environmental Studies (IVM), Vrije Universiteit Amsterdam, Amsterdam, The Netherlands; [b]FLEGT Independent Market Monitoring (FLEGT IMM), International Tropical Timber Organization, Yokohama, Japan; [c]Department of Biology and Institute of Environmental and Interdisciplinary Sciences, Carleton University, Ottawa, Ontario, Canada; [d]Snow Leopard Trust, Seattle, WA, USA; [e]Sorbonne Université, CNRS, Station Biologique de Roscoff, Roscoff, France; [f]Institute of Physical Geography and Landscape Ecology, Leibniz Universität Hannover, Hannover, Germany; [g]Department of Science, Technology, Engineering and Public Policy, University College London, London, UK; [h]ISOE - Institute for Social-Ecological Research, Research Unit Biodiversity and People, Frankfurt am Main, Germany; [i]UNESCO Centre for Water Law, Policy & Science, University of Dundee, Dundee, UK; [j]CIRAD (Centre de Coopération Internationale en Recherche Agronomique Pour le Développement), UMR DIADE, Montpellier, France; [k]United Nations University, Institute for Environment and Human Security, GLOMOS Programme at Eurac Research Viale Druso 1, Bolzano, Italy; [l]Eurac Research, Centre for Global Mountain Safeguard Research, Bolzano, Italy; [m]Costeras, Universidad Autónoma de Baja California SurDepartamento de Ciencias Marinas y , La Paz, México; [n]University Felix Houphouet-Boigny, WABES project, Abidjan, Côte d'Ivoi

ABSTRACT

Effective knowledge exchange at science-policy interfaces (SPIs) can foster evidence-informed policy-making through the integration of a wide range of knowledge inputs. This is especially crucial for conservation and sustainable use of biodiversity and ecosystem services (ES), human well-being and sustainable development. Early-career researchers (ECRs) can contribute significantly to knowledge exchange at SPIs. Recognizing that, several capacity building programs focused on sustainability have been introduced recently. However, little is known about the experiences and perceptions of ECRs in relation to SPIs. Our study focused on SPI engagement of ECRs who conduct research on biodiversity and ES, as perceived and experienced. Specifically, we addressed 'motivations', 'barriers' and 'opportunities and 'benefits'. A total of 145 ECRs have completed the survey. Our results showed that ECRs were generally interested to engage in SPIs and believed it to be beneficial in terms of contributing to societal change, understanding policy processes and career development. Respondents perceived lack of understanding about involvement channels, engagement opportunities, funding, training, perceived credibility of ECRs by other actors and encouragement of senior colleagues as barriers to engaging in SPIs. Those who have already participated in SPIs generally saw fewer barriers and more opportunities. A key reason for dissatisfaction with experience in SPIs was a lack of impact and uptake of science-policy outputs by policymakers – an issue that likely extends beyond ECRs and implies the need for transformations in knowledge exchange within SPIs. In conclusion, based on insights from our survey, we outline several opportunities for increased and better facilitation of ECR engagement in SPIs.

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1. Introduction

Science-informed policy making has become crucial to cope with complex global challenges. For the conservation and sustainable use of biodiversity and ecosystem services (ES) interactions between scientists and policymakers are widely acknowledged to be essential (Balvanera et al. 2020; Krug et al. 2020). Global examples of such interactions include the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC). On regional or local levels, it could be a less formal interaction between researchers and policy-makers, such as co-developing collaborative projects or discussions with local government officials. Spaces for such interactions are referred to as science-policy interfaces (SPIs) – the intersection between science and policy at different scales, where scientists, policymakers and other stakeholders exchange ideas and co-produce knowledge for policy and research (Van den Hove 2007; Crouzat et al. 2018). Effective knowledge exchange at SPI has the potential to ultimately improve the conservation and sustainable use of biodiversity and ES by identifying capacity, knowledge and data needs within policy contexts and thus fostering evidence-based policy-

CONTACT Anna Filyushkina anna.filyushkina@vu.nl

*The first three co-authors contributed equally in leading authorship of the paper and should be considered joint first author.

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and decision-making (Reed et al. 2014; Gustafsson 2018; Krug et al. 2020).

Early Career Researchers (ECRs) are considered promising players in SPIs for intergenerational knowledge sharing and capacity building (Lim et al. 2017; Bethke et al. 2018; Gustafsson, 2018 Rosen 2018). While definitions for ECRs are nebulous and vary from country to country (Nicholas et al. 2017), many of them are degree- and position-contingent, proposing that ECRs should be in the process of obtaining or already have their doctorate, bound by an upper limit of a tenure or tenure-equivalent research position (Nicholas et al. 2017; Hein et al. 2018; Hossain et al. 2018). For instance, the IPBES fellowship programme defines ECRs as those generally not over 35 years, with 5–10 years of work experience after having completed their highest relevant degree (Gustafsson and Lidskog 2018).

Engaging ECRs in SPIs can be beneficial for both the ECRs and SPIs. ECRs can achieve policy impact from their research, contribute to social justice (Cvitanovic et al. 2015; Evans and Cvitanovic 2018) and learn how to communicate scientific knowledge to policy actors, as well as expand professional networks, provide opportunities to collaborate and develop leadership and other skills (Lim et al. 2017; Bethke et al. 2018; Gustafsson, 2018a; Gustafsson et al. 2019). ECR engagement in SPIs can build future science-policy capacity to solve complex challenges (Cumiskey et al. 2015; Lim et al. 2017; Gustafsson 2018; Jeanson et al. 2019). ECRs themselves bring a wealth of expertise (Burgman et al. 2011; Lim et al. 2017; Evans and Cvitanovic 2018) and contribute to developing a holistic understanding of the full range of information and knowledge on science-policy issues, hence increasing policy and societal relevance (Washbourne et al. 2020). Moreover, once active in SPIs, ECRs would be in a valuable position to inspire and mentor their peers to follow them in participating in SPIs (Bethke et al. 2018).

Depending on their values and capabilities, ECRs can participate in SPIs through various roles (Bednarek et al. 2018; Crouzat et al. 2018). For instance, ECRs can conduct research which directly involves policymakers or decision makers in co-production processes based on the priorities and needs of these potential knowledge users (i.e. Horizon 2020 projects). Alternatively, ECRs can engage with policymakers through more formal regional, national or global SPIs and science-policy processes such as IPBES. Recognizing the benefits of engaging ECRs in SPIs, a number of sustainability-focused capacity building programs have recently been introduced at different scales (e.g. IPBES fellowship, E4D's Science to Policy Accelerator, AAAS Science & Technology Policy Fellowships, Science Outside the Lab, STPI's Policy Fellowship Program, Canadian Science Policy Fellowship by Mitacs, etc.) (AAAS 2017; Bernstein et al. 2017; Canadian Science Policy Fellowship; Petes and Meyer 2018; Hetherington and Phillips 2020). Some of these capacity building programs are run by established SPIs and their platforms, where ECRs work alongside senior researchers. For instance, IPBES offers fellowship opportunities for ECRs to contribute to science-policy assessments, working closely with senior researchers and policymakers, by reviewing literature, arranging collaboration or writing reports (Lim et al. 2017; Gustafsson 2018; Gustafsson et al. 2019, 2020). In such circumstances, ECRs not only gain first-hand experience in SPIs but are also provided arenas where their contributions have the opportunity to be trusted and valued by both more senior experts and policymakers (Gustafsson et al., 2019). Moreover, in the case of IPBES fellows, they are provided with mentors from the assessments as well as training on various aspects of IPBES processes, science-policy in general, and science communication (Gustafsson 2018).

Despite the increasing acknowledgement of the importance of ECR engagement in SPIs (Evans and Cvitanovic 2018), little is known about the experience and perception of SPIs among those conducting biodiversity and ES research. Several studies have investigated the IPBES fellowship to examine implications, expectations and needs in engaging ECRs in IPBES (e.g. Lim et al. 2017; Lambini and Heubach, 2017; Gustafsson 2018; Díaz-Reviriego et al. 2018). However, no studies have explored the engagement of ECRs in SPIs beyond IPBES.

Mapping ECRs' experiences and perceptions of engagement in SPIs in various scales is crucial in diagnosing its current state and identifying opportunities for moving towards more ECR engagement in SPIs and possibly, more effective science-policy knowledge exchange. This study aims to understand ECRs' experiences and perspectives engaging with SPIs in different capacities. We explore perspectives from ECRs who have engaged with SPIs as well as those who have not yet engaged in SPIs. We specifically explore if and why ECRs want to be involved in SPIs ('motivations') and what opportunities they perceive for participation in SPIs ('opportunities'). We also identify challenges ECRs face engaging in SPIs ('barriers') and the perceived benefits of ECR engagement in SPIs for both ECRs and SPIs ('benefits').

2. Material and methods

2.1. Data collection

We developed an online survey to investigate ECR experiences and perceptions of engaging in SPIs. In

this study, we considered different types of SPIs at various levels of social organisation representing different roles and positions researchers adopt: from global platforms such as IPBES to the less formal? interactions between researchers and policy-makers, such as developing collaborative projects or discussions with local government officials (as communicated to survey respondents during survey deployment – see Supplementary materials p.3). As previously articulated, there are several different definitions for ECRs. For the purpose of this study, we used the following definition: 'a person with five or fewer years of research experience after their highest completed degree (MSc or PhD), researching biodiversity and/or ES'. By using such a definition, we aimed to filter our survey participants based on their level of academic experience rather than their age as the experience level is more relevant to our aim. Involvement in SPIs was not a prerequisite because we were interested in responses from respondents with SPI experience and also those without.

The survey, composed of three sections, was designed to understand the background of the respondents (section 1), investigate engagement experience in SPIs (section 2) and examine motivations, barriers, opportunities and benefits of ECRs' involvement in SPIs (section 3) (the survey can be found in the Supplementary material 1). We chose to focus on these four aspects (motivations, barriers, opportunities and benefits) for mapping the state and perceptions of participation in SPIs, inspired by the student engagement framework by Lawson and Lawson (2013). The survey began with a section on respondents' background (age, gender, nationality, country of residence, employment status, etc.), which was also used to filter out non-eligible (non ECR) respondents. The second section of the survey contained a series of questions on respondents' experience of engagement in SPIs (if they have engaged) through a mix of open-ended and close-ended (i.e. multiple-choice) questions. It covered such aspects as motivations, types of activities performed, level of satisfaction and desire to engage in SPIs in the future. With the exception of open-ended questions asking for further details or clarification, all questions were mandatory for the respondent to complete in order to move further in the survey. For those who haven't previously engaged in SPIs, open-ended questions inquired whether and why they would like to engage in SPIs in the future. If they didn't wish to engage in SPIs, an open-ended question asked why not and this set of respondents was eliminated from subsequent sections of the survey. The other two categories of respondents (those who have previously participated in SPIs, and those who haven't but would like to) were then presented with a series of statements in section 3, which they answer using a five-point Likert-style scale. The statements were worded as questions and not as affirmations, to avoid agreement bias by the respondents. These statements cover different aspects of perceived opportunities, barriers, motivations and benefits for engaging in SPI. Ethics approval for the project was obtained from the Vrije Universiteit Amsterdam (the Netherlands), where the corresponding author is employed.

In the period from 2 to 23 November 2019, the online survey was tested by 13 people, constituting team members not directly involved in survey development or colleagues of authors. A revised version was developed and was then uploaded to the KoBo Toolbox platform (https://www.kobotoolbox.org/). The online survey was open for data collection from 16 January until 1 April 2020. Respondents were recruited through mailing lists of international networks for ECRs researching biodiversity and ES, such as Young Ecosystem Services Specialists (YESS) network, IPBES Fellows and the Future Earth ECR Network of Networks. Respondents were also encouraged to share the survey with their peers and professional networks. These activities were supplemented with recruitment posts to social media channels (Twitter and Facebook) by the research team, which has been shown to be helpful in leveraging contacts in snowball sampling (Kirchherr and Charles 2018). A call for survey participants was also featured in the Ecosystem Services Partnership (ESP) newsletter.

2.2. Analysis

We received a total of 160 survey responses. Data cleaning involved the removal of mostly incomplete answers and duplicates and any submissions that did not fit within our definition of ECR. This reduced the final sample of survey submissions retained to 145. On average, respondents took 15 minutes to complete the survey.

2.2.1. Quantitative analysis

Likert-style opinion statements were transformed from categorical-ordinal to numerical-discrete, e.g. no opportunities = 1, few opportunities = 2, some opportunities = 3, many opportunities = 4. Correlations were conducted to explore relationships between Likert-style opinion statements and both socio-demographic characteristics and SPI experience. Low-moderate correlations or higher were explored further using student's *T*-test or one-way ANOVA to explore statistically significant differences. Any one-way ANOVA, which demonstrated statistically significant differences, was followed with a post hoc Tukey's test to detect where statistically significant pairwise differences occurred.

2.2.2. Qualitative analysis

Open-ended questions were analysed using a qualitative thematic analysis (Guest et al. 2012). The responses were reviewed and categorized into thematic codes, and the frequency of each category was quantified. Authors cross-checked categorization on each question to enhance objectivity in categorization decisions. When disagreements occurred, they were discussed so that the resolutions informed subsequent assessments. Samples of answers were extracted as vignettes to provide detailed examples of ECR perceptions.

3. Results

3.1. Socio-demographic characteristics of the sample

Our sample of survey responses consisted of 145 respondents, with a fairly even distribution between traditional genders: females (53%) and males (45%); 2% chose not to disclose a gender (category 'other' received no responses). The age of respondents ranged from 22 to 48 years old with a mean of 31 (standard deviation = 4.7). Geographically, our sample was considerably biased towards respondents from two countries (Germany and India) which account for nearly half of both nationalities and countries of residency (Nationality: 23% Germany, 23% India; Residency: 28% Germany, 20% India). Twenty-one countries (15%) were represented by a single national respondent, while twenty-four (24%) were represented by a single resident respondent (Fig. S2).

Most respondents had a Master's degree (61%) or a Doctoral degree (34%). A few respondents (5%) had only a Bachelor's degree at the time of survey participation. The respondents were mainly employed by universities or research institutes (79%) with the remaining smaller portion employed within non-governmental organisations (NGOs) (11%), public sector (4%), private sector (2%) or other types of organisations (4%; e.g. freelance, self-employed). Figures for these results are presented in Supplementary material 2 (S1–3).

3.2. ECRs' experience engaging in SPIs

About 60% of the respondents have participated in SPIs, most of them have done so for 1–2 or 3–5 years (33% or 21% respectively). The respondents who had participated in SPIs were involved mainly in policy research (22%), collating information and writing policy briefs (20%; e.g. writing report cards), or stakeholder engagement (16%; e.g. coordinating events like symposiums or capacity building programs) (Table S2). Many of the ECRs who have completed our survey responded that they had engaged policymakers in their research projects, often focusing on policy measures, management strategies, legislation and governance. Among those who have no SPI experience, only 10% did not wish to participate in SPIs in the future.

The majority of respondents who have participated in SPIs were satisfied with their involvement (44% were satisfied and 15% were very satisfied; n = 85). Reasons for satisfaction include professional and personal benefits, such as networking and observing the uptake of science in practice first-hand. For instance, one ECR commented 'Being involved in SPIs allows us to know more about: how the science is being seen by the politicians; what are the priorities of the policy; how we can meet the two sides; and how the research/science can respond to the political issues.' Another respondent stated 'My results were used to develop a land management plan.' As for networking, one explained 'the process has a great influence on networking – collaborations and awareness raising to ES', and another mentioned 'I got to know lots of interesting and high level people, who have amazing experiences in science, policy and SPIs.'

Meanwhile, 34% of the respondents were dissatisfied with their experience in SPIs (32% were not so satisfied and 2% were not satisfied at all). The reasons for their dissatisfaction include uncertainties in the uptake of science policy research, challenges in the engagement process or mismatches between expectations. For example, one participant stated 'not satisfied because it is rare to see positive outcomes from attempts to improve communication among parties in SPIs. (It is) difficult to tell whether the work has been successful', and another mentioned 'The research results have only had limited uptake on the policy end.' Regarding challenges in the engagement process, one commented 'I have faced limitations in the scope of research . . . as it is common that policymakers already know what they want to implement and are closed to innovation.' As for mismatches between expectations, one respondent explained 'I was less involved and felt that my work had less impact than expected'.

3.3. ECRs in SPIs: perceived and/or experienced motivations, opportunities, barriers and benefits

ECRs who participated or wished to participate in SPIs in the future (96% of the respondents) were asked about their motivations, perceptions of opportunities and barriers as well as benefits to both ECRs and SPIs. Figure 1 shows the overall results from 19 Likert-scale statements, below we will go deeper into each section and also complement it with answers from other questions.

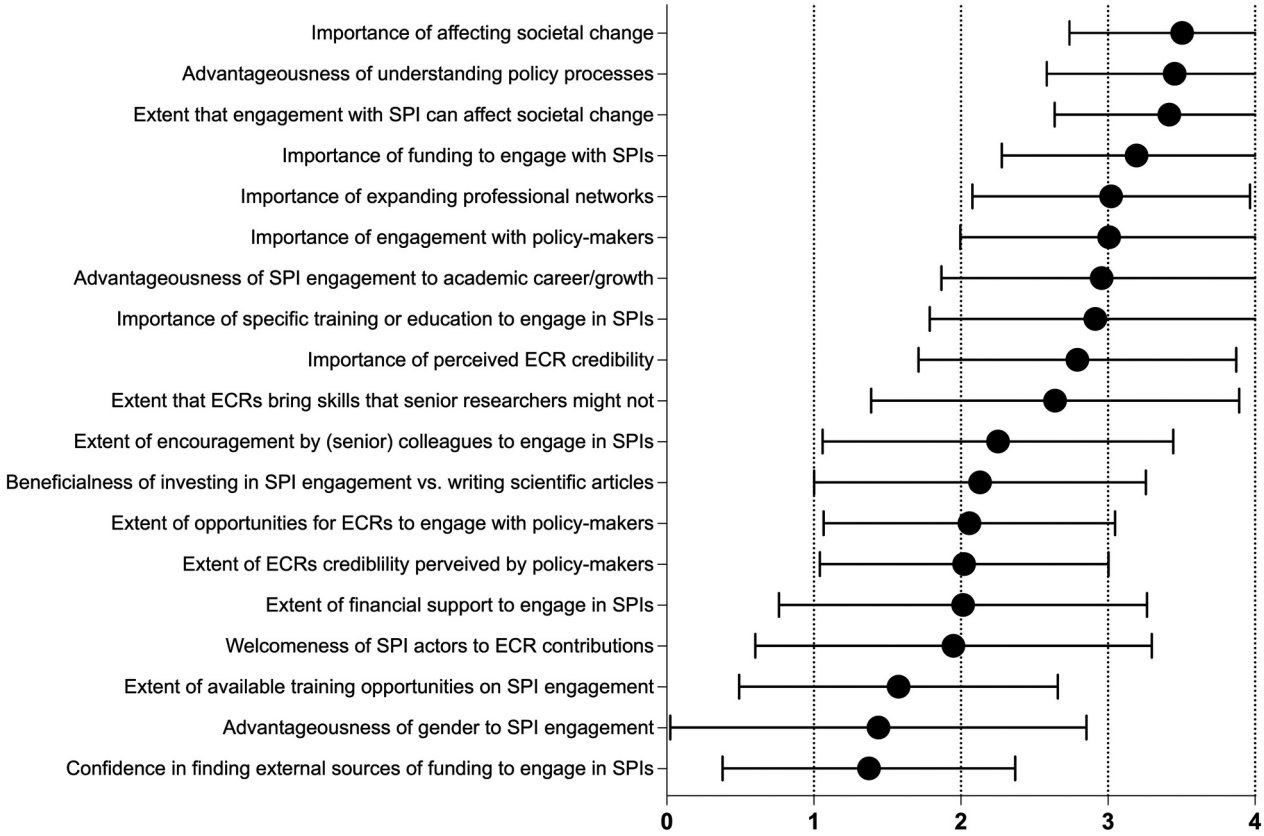

Figure 1. Mean (± SD) responses to 19 Likert-style opinion statements from $n = 139$ respondents about early-career researchers' (ECRs') participation in science-policy interfaces (SPIs), ordered from highest to lowest mean. Six remaining respondents were excluded from answering Likert-scale statements since they have not participated in SPIs, nor they wished to do so in the future. Breakdown and distribution of the raw data of responses for each category can be found in Fig S4. X-axis scale (0 = Not sure, 1 = No/Not, 2 = Few/Not so/to a little extent, 3 = Some/To some extent, 4 = Many/Very/To a great extent).

3.3.1. Motivations

Encouragingly, the desire of ECRs to participate in SPIs in the future is high. Most of the respondents thought engaging in SPIs was an important undertaking for ECRs (Figure 2-12, 79%) and expressed their willingness to participate in SPIs in the future (90%) (Table 1). Participants were most interested in conducting 'research for policy', followed by 'training and capacity-building', 'public communication' such as on social media, 'information collation' and 'writing reports for policy' (Table 1).

Among the participants who acknowledged the importance of ECR engagement in SPIs, the majority explained that it enabled them to contribute to achieving societal change (e.g. by enhancing the impact of research and contributing to a sustainable future with research) (Figure 2-13). In open-ended questions, some responded that ECR engagement in SPIs helps build expertise (e.g. understanding co-production of research with policymakers and other stakeholders, learning science communication, strategically positioning their research for funding and understanding research demands by society). Others think ECRs' involvement in SPIs is important for the value of ECR-specific contributions, such as their fresh and creative ideas, perspectives, enthusiasm, novel approaches and academic discipline knowledge. SPIs were also regarded as a valuable networking

Table 1. Early-career researchers' motivations, activities of interest and willingness to participate in science-policy interfaces (SPIs).

	Total	SPI-experienced	SPI-inexperienced
No. of respondents	145	85	60
Motivations (%)			
Societal change	76.6	76.5	76.7
Appliance of research	75.9	77.6	73.3
Academic growth	44.8	44.7	45
Networking	43.4	38.8	50
Other	4.8	8.2	0
Activities of interest (%)			
Research for policy	67.6	71.8	61.7
Training	57.9	58.8	56.7
Public communication	51	47.1	56.7
Information collation	48.3	54.1	40
Stakeholder engagement	46.9	58.8	30
Project coordination	43.4	51.8	31.7
Research on SPI	37.2	47.1	23.3
Other	1.4	1.2	1.7
Willingness to participate in the future (%)			
Yes	89.7	89.4	90
No	5.5	2.4	10
Not sure	4.8	8.2	0

Please note that the figures are the results of multiple-choice questions, hence the sum may exceed 100%. The percentages were calculated based on the number of respondents in each category (total, SPI-experienced and SPI-inexperienced).

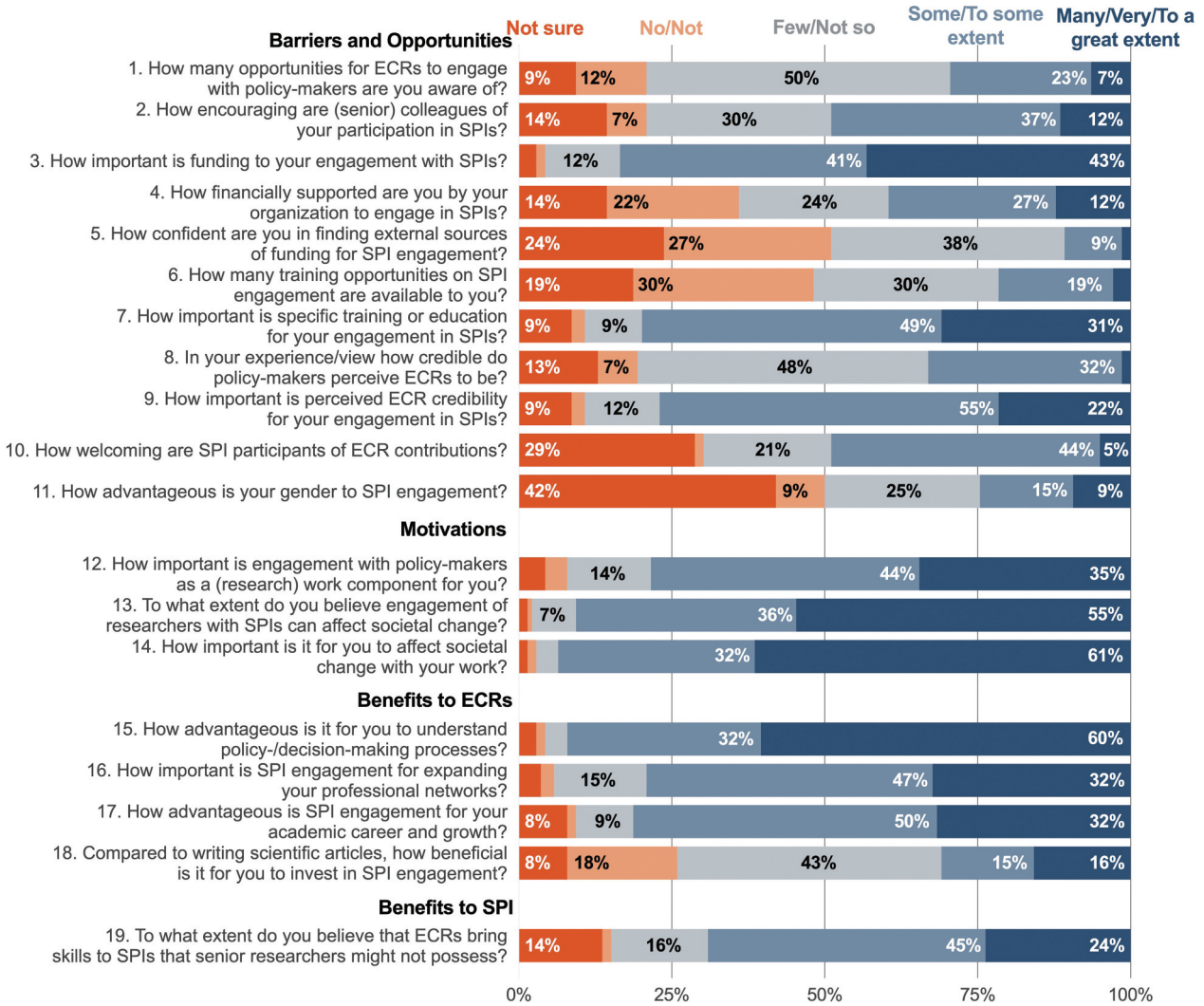

Figure 2. Stacked bar plot of responses to Likert-style online survey questions $n = 139$ respondents about early-career researchers' (ECRs') participation in science-policy interfaces (SPIs).

opportunity, and a platform to provide experience on applied research, or inspire future research.

According to results from the Likert-style opinion statements, engagement with policymakers was important (44%) or very important (35%) for ECRs as a work component (Figure 2-12, Figure S4). Respondents (55%) were clear about their belief that engagement of ECRs with SPIs can affect societal change to a great extent (Figure 2-13). Likewise, the majority of respondents (61%) felt it was very important for them to affect societal change within their work (Figure 2-14). Only 6% of the respondents indicated that they had little desire to engage in SPIs, providing the rationale that they would rather focus on other research-related activities (e.g. publications) and that policy should be the domain of those already working actively and embedded in SPIs. Participants described a desire to be actively acknowledged for their participation as ECRs in SPIs – tangible outputs including formal co-authorship, fellowship opportunities, acknowledgements as young experts conducting research on biodiversity and ES by more senior authors and experts.

3.3.2. Barriers and opportunities

The results of Likert-style opinion statements show ECRs' perceptions on a range of barriers and opportunities categorised as below:

- Engagement opportunities: The majority of respondents (62%) perceived no or few opportunities for them to engage with policymakers (Figures 1, 2–1 and 3, Figure S4).
- Encouragement by senior colleagues: There was a relatively close split between ECRs on whether they perceived their senior colleagues as 'not so encouraging' (30%) or 'encouraging' (37%) of ECR participation in SPIs (Figures 2–3).
- Training: Specific training or education for engagement in SPIs was considered important or very important by 80% of respondents (Figure 2-7). Yet many of them thought that there were none (30%) or too few (30%) such training opportunities (Figure 2-6).

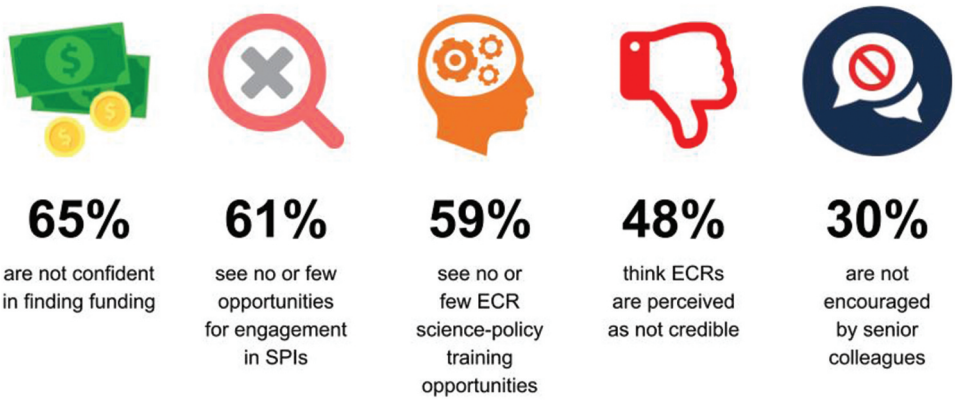

Figure 3. Barriers early-career researchers (ECRs) perceive in engaging in the science-policy interfaces (SPIs) (n = 139).

- Credibility: ECR credibility was important or very important for engagement in SPIs as perceived by the majority of respondents (77%) (Figure 2-9). Nearly half of the respondents (48%) felt that policymakers perceived ECRs to be not so credible based on their views or experiences (Figure 2-8). Conversely, about a third (32%) also felt that policymakers saw ECRs to be credible (Figure 2-8). At the same time, many respondents (44%) thought that their contributions were welcomed in SPIs (Figure 2-10).
- Gender: Gender was perceived neither advantageous nor disadvantageous for engagement in SPIs by respondents (Figure 2-11).
- Funding: Funding was perceived as important or very important for ECR engagement in SPIs by the large majority of respondents (84%), thus constituting an opportunity or a barrier to engagement based on the availability of funding (Figures 2-3). The perceived level of financial support for participation in SPIs by their organisations was rather evenly distributed: 'not supported at all' (22%), 'not so supported' (24%) and 'supported' (27%) (Figure 2.4). Many respondents (65%) were not confident in their ability to find external sources of funding for engagement in SPIs (Figures 2-5).

Among a subgroup of respondents who have not participated in SPIs, 90% indicated that they are interested in participating in the future. Despite the high interest in participating in SPIs, they did not participate previously due mostly to lack of awareness on how to get involved (73% of the respondents without SPI experience) (Table 2).

Table 2. Reasons of early-career researchers for not having participated in science-policy interfaces in the past (n = 60).

Reasons for nonparticipation in the past	Frequency	Percentage
I did not know how to get involved	44	73.3
I had no funding	20	33.3
Other	9	15
I was not interested	7	11.7
I was discouraged by my supervisor	5	8.3
I did not speak the language, in which the discourse was taking place	3	5

3.3.3. Benefits to ECRs and SPIs

The majority of respondents (60%) believed ECR engagement in SPIs to be very advantageous for their understanding of policy-making processes (Figures 1 and 2-15, Figure S4). Similarly, engagement in SPIs was considered beneficial for both a) expanding professional networks (79%) and b) academic career development and growth (82%) (Figure 2-16 & 17). Other benefits for engaging in SPIs which respondents listed include achieving societal change (e.g. enhancing the impact of research and contributing to a sustainable future); skill-building (e.g. co-working with policymakers and other stakeholders; communicating science, strategically positioning research for funding; and understanding societal research demands), and obtaining new inspiration and motivation for research.

In terms of trade-offs between writing scientific articles and investing time in SPIs, many respondents (43%) felt investing in SPIs has about the same benefits; while 31% felt investing in SPIs offered more or much more benefits, and 18% felt it offered less benefits to writing scientific articles (Figure 2-18).

About half of respondents (45%) thought ECRs bring skills to SPIs that senior researchers might not possess (Figures 1 and 2-19). In a multiple-choice question, respondents identified those skills to be the following:

- interdisciplinarity (chosen by 83% of the respondents),
- insights and ideas (70%),
- flexibility (58%),
- familiarity with public communication (46%),
- proficiency in new technology (37%),
- time (35%), and
- policy experience (32%).
- others (3%; e.g. expert knowledge and enthusiasm)

3.3.4. Impact of SPI experience on ECRs' perception of motivations, barriers and benefits

A paired two-sample *t*-test demonstrated that having SPI experience or not affected respondent perceptions

on motivations, barriers and benefits of engaging in SPIs. There was a difference between the group of ECRs who have participated in SPIs before and the group without experience in their responses to several statements (statement 1, 2, 4, 6, 10, 17) at a statistically significant level (Figure 4). Respondents who have been involved in SPIs were more optimistic in their outlook. For example, ECRs with experience in SPIs tend to believe (or have experienced that?) there are more opportunities ($t(137) = 3.438$, $p < 0.01$), senior colleagues are more encouraging ($t(137) = 5.352$, $p < 0.0001$), they are more financially supported ($t(137) = 8.292$, $p < 0.0001$), there are more training opportunities ($t(137) = 3.732$, $p < 0.001$), SPIs are more welcoming of ECR contributions ($t(137) = 4.131$, $p < 0.001$), and engagement in SPIs is more important for academic and career growth ($t(137) = 3.209$, $p < 0.01$). More details on correlation analysis can be found in Supplementary materials 2 (Figures S5–6 and Table S1).

3.3.5. Link between respondents' nationality and perception of motivations, barriers and benefits of engaging in SPIs

As our sample has a skewed distribution of nationality and residency (majority Germany and India), we carried out a *t*-test to examine any possible influence of nationality and residency on the statement responses. The result showed mainly German nationals and residents were consistently more conservative than other nationals and residents ($P \leq 0.05$–0.001). That is, German nationals and residents consistently, on average, selected more negative responses to likert-style opinion statements than did the rest of respondents (who, on average, selected more positive responses to the 19 likert-style statements). Indian nationals and residents demonstrated no statistical differences between non-German nationals and residents (Fig. S6; limitations in the discussion).

4. Discussion

This study surveyed 145 ECRs researching biodiversity and ES in regard to their experience and perceptions of engagement in SPIs.

4.1. Most ECRs are eager to participate in SPIs

Our findings demonstrated that ECRs were generally interested in engaging in SPIs and ECRs' motivations were aligned with the expected benefits of participation in SPIs, mainly societal change and career development. In the past decade, there has been an increasing emphasis on fostering societal change by researchers (Evans and Cvitanovic 2018; Singh et al., 2019) which likely extends to ECRs' desires to engage in SPIs. The benefits included influencing society, developing careers by increasing policy relevance of studies, gaining inspirations for research and expanding professional networks. As the motivations and perceived opportunities were closely aligned, it is important to ensure opportunities are available in order to motivate ECRs to engage and contribute beneficially in effective knowledge exchange in SPIs.

4.2. Support from supervisors and institutions matter

A range of barriers affect ECRs' motivations for participation in SPIs and participation itself. Some of these barriers are not specific to engagement in SPIs (like lack of funding) but rather could be universal barriers for ECRs and present itself in other types of activities ECRs engage (like conferences and travel). Barriers also exist for all scientists seeking to engage with SPIs; however, some barriers are especially relevant for ECRs, due to their often-unstable position within academia, lack of scheduling and financial security and flexibility, etc. (Jaeger-Erben et al. 2018). Our results indicated that barriers like placing priority on writing scientific publications and a lack of encouragement by supervisors or their institutes hinder ECRs involvement in SPIs. ECRs' activities are strongly directed by their supervisor and institution and ECRs themselves have high insecurity in their career with short-term contracts and little stability (Phillips and Heywood-Roos 2015; Kellard and Śliwa 2016; Evans and Cvitanovic 2018). This suggests that institutional and senior researcher recognition of the importance of involvement in SPIs is a critical first step in ECR participation in SPI.

4.3. First engagement in SPIs presents a bottleneck

ECRs without any experience in SPIs tended to see fewer opportunities to engage in and to train for SPIs and were less confident in finding funding to participate in SPI, compared to those experienced in SPIs. It is likely that the ECRs with experience in SPIs are better positioned (e.g. have a greater awareness and knowledge) to find funding and opportunities to engage in science-policy using the network they developed through their initial involvement in SPIs. Gustafsson (2018) explained, for example, that IPBES' fellowship program allowed ECRs to expand their professional and social network related to science policy. Therefore, while several engagement opportunities now exist (examples in introduction), developing and exposing more early-career targeted capacity building programs in SPIs, in terms of both number and diversity of roles, would increase the number of

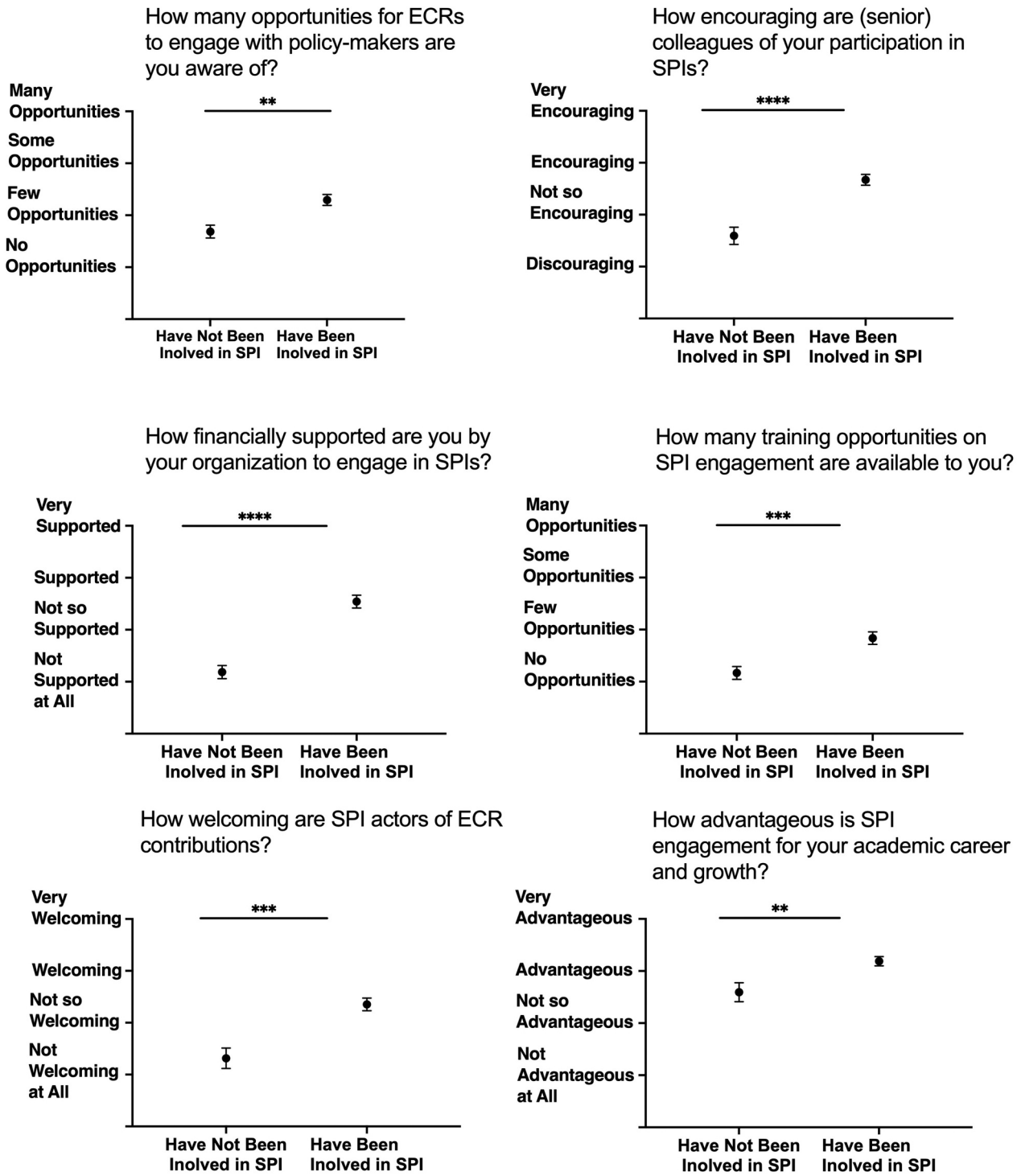

Figure 4. Mean (± SE) responses to Likert-style opinion statements stratified by whether respondents have or have not been involved in science-policy interfaces (SPIs) (n = 139). * P ≤ 0.05; ** P ≤ 0.01; *** P ≤ 0.001; **** P ≤ 0.0001 based on paired two-sample *T*-test.

first-time engagement, which seems to be a bottleneck. These findings also point to the need for additional research on why many ECRs see only few opportunities despite the existing programs focused on ECR engagement in SPIs. ECRs' perceptions on their opportunities to engage in SPIs are likely to be influenced by a variety of factors such as personal past experiences, available individual incomes, current geographic location, gender and others. This awareness reinforces our consideration that we need better understanding of all factors affecting ECR participation in SPIs.

4.4. ECRs can and want to play bigger roles in SPIs

ECRs were mostly engaged in SPIs through knowledge generation and knowledge assimilation. Engagement in these types of activities is likely strongly linked to ECR skills in research and

production of knowledge (van Kerkhoff and Lebel 2006). Knowledge co-production in SPIs is often transdisciplinary, which ECRs are increasingly skilled in Haider et al. (2018) and Hackenburg et al. (2019). ECRs are able to rethink, combine and apply classical knowledge regimes such as western sciences alongside other knowledge regimes such as Indigenous and local knowledge in the co-production of knowledge with policymakers and other stakeholders and rightsholders (Felt et al. 2013). ECRs were least engaged in knowledge dissemination, capacity building, project coordination and stakeholder engagement. Given that ECR experiences in SPIs are limited to only one or a few types of engagement such as knowledge generation rather than a diversity of roles could also mean that ECRs are less visible in SPIs than their senior colleagues. This could further reinforce a perception of lack of expertise among ECRs and difficulty in establishing relationships with policymakers and more senior colleagues (Burgman et al. 2011; Evans and Cvitanovic 2018). Thus, the full potential of ECRs engaging in SPIs remains underutilised. SPIs constitute a wide spectrum of roles, and ECRs can likely fulfil several of these functions and roles (Lim et al. 2017; Bednarek et al. 2018). ECRs are also familiar with emerging communication and engagement technologies and understand social connectivity (Jeanson et al. 2019). These skills can be effectively utilised in knowledge dissemination, project coordination and stakeholder engagement.

4.5. SPI programs for ECRs should be more visible

Ninety percent of our participants wished to engage in SPIs, however only 60% have such experience. This could be indicative that opportunities for SPI engagement are scarce and/or competitive or that ECR respondents were unaware of them or a combination of both. It could also relate to the barrier of engagement discussed above, where performance criteria, institutional cultures and reward systems favour other kinds of outputs such as publications and discourage SPI engagement. Half of our respondents without experience in SPIs were not aware of opportunities, while organisations across the world are increasingly offering formal opportunities for scientists to engage with SPIs. More than 150 science-policy opportunities for ECRs have been identified across 50 countries (AAAS 2017; Lim et al. 2017; Evans and Cvitanovic 2018). While there seem to be global opportunities to engage with SPIs through fellowships, internships and placements, which often are communicated through professional and institutional networks, the lack of awareness of these opportunities among our ECR respondents suggests that these opportunities need to be better communicated. Opportunities like IPBES fellowships could be made more visible by targeting early-career networks, e.g. Young Ecosystem Services Specialists network (YESS), Young Earth System Scientists, the Global Youth Biodiversity Network (GYBN), the Biodiversity Science-Policy Interfaces Network for Early Career Scientists (BSPIN), Future Earth ECR Networks of Networks, Global Young Academy, IPBES fellows, Global Sustainable Futures. Further, ECRs interested in SPIs could join and network with IPBES and these early-career networks.

4.6. ECRs may hold the skills required for engaging in SPIs, but there is still a gap

Many ECR respondents perceived themselves as potentially making a significant contribution to SPIs. These contributions range from specific areas of engagement and outputs, such as producing policy briefs, to a more general sense of bringing personal and interpersonal attributes and experience to SPIs dominated by more senior voices. ECRs in our study believed they bring skill sets, which key literature identifies as required capacities for SPIs: communication skills, understanding of both science and policy contexts, expansive stakeholder networks, honesty, humility, openness and resilience (Chapman et al. 2015; Evans and Cvitanovic 2018); combination of conflict management and facilitation skills (Gustafsson et al. 2020), and a recognition of the value of different perspectives (Patterson et al. 2013; Haider et al. 2018). The insights from this study therefore help to strengthen the case for, and verify the perception of, the value of these attributes from theory to practice.

4.7. ECRs' roles in SPIs are limited

Our result showed a mismatch between the current and desired roles of ECRs in SPIs. While ECRs demand a variety of activities, such as research for policy, training, public communication, information collation and project coordination, they have only really fulfilled roles limited to research for policy and information collation. The mismatch suggests ECRs' tasks need to be diversified to better accommodate their competences and motivations. Also, capacity building programs need to cover training for a variety of competences required for SPIs, such as project coordination, public communication and dialogue facilitation, which are competencies often lacking even among senior researchers (Gustafsson et al. 2020).

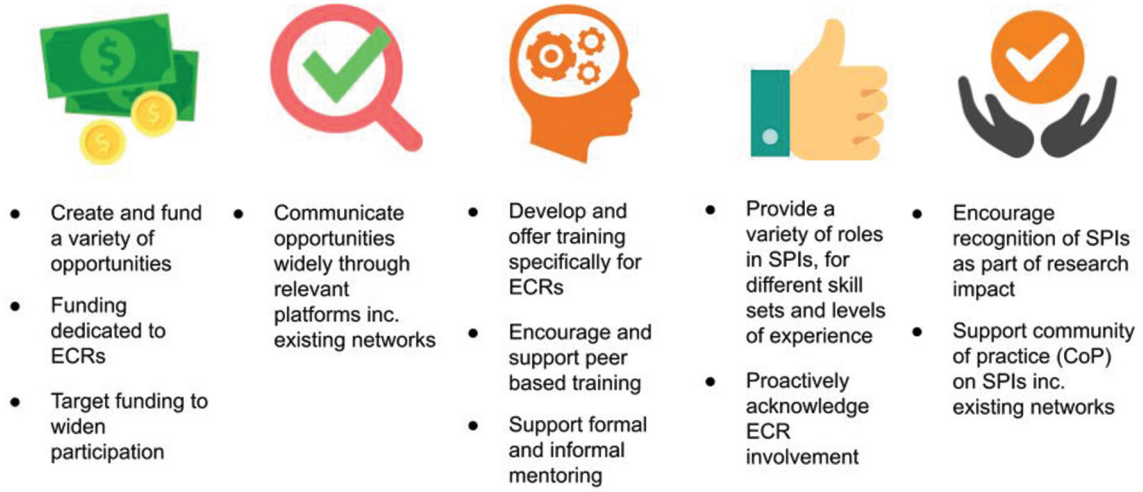

Figure 5. Suggestions to better engage early-career researchers (ECRs) in science-policy interfaces (SPIs).

4.8. Methodological considerations and limitations

We recognize some limitations, with possible implications for our analysis and conclusions. The qualitative and quantitative research presented is based on a limited survey sample of the 145 respondents. In our data, demographic factors manifested bias in the results only for German nationals and residents who were statistically more conservative than other participants in their survey responses. The possibility exists that certain effects were underestimated due to this geographical bias from respondents from Germany. The clear and detectable statistical bias from German (nationals and residents) may result in consistently lower scores to likert-style opinion statements in our data, on average, than a more well-represented and random sample from ECRs across the globe interested in SPIs. To explore if other similar geographical biases exist, further research with a larger and random sample would be necessary.

Participation in the online survey was also voluntary and in English only, thus likely presenting an avidity bias and self-selection bias with English-speaker participants more interested in SPIs, ecosystem services, and biodiversity more likely to be part of the mailing lists and social media channels we targeted and thus more likely to participate in the survey. We also acknowledge the limited reach of online snowball surveys, which can only reach those who have internet access (Szolnoki and Hoffmann 2013).

5. Conclusions and future research

Our study focused on ECRs who conduct research on biodiversity and ES and their engagement in SPIs as perceived and experienced by ECRs. Our findings demonstrated that ECRs were generally interested in engaging in SPIs. ECRs in our survey perceived the lack of understanding about involvement channels, engagement opportunities, funding, training, perceived credibility of ECRs by other actors and encouragement of senior colleagues as barriers to engaging in SPIs. Those who have already participated in SPIs generally had more positive experiences and perceived less barriers and more opportunities. ECRs with no SPI experience, yet interested in being involved in SPIs, encountered barriers of not knowing how to get involved, being discouraged by supervisors or pressures to focus on research (e.g. publication). Activities for ECRs who have been involved in SPIs were limited to research for policy or information collation despite ECRs wish to contribute to a variety of activities including research on SPIs, training and project coordination. A key reason for dissatisfaction with SPI experiences among ECRs was perceived uncertainties in the uptake of outputs of work by policy makers/society. This, however, may likely be an issue extending beyond just ECRs, suggesting work done at the SPI itself (i.e. how it's organized, performed and communicated) needs to change to increase the uptake of scientific evidence in policy contexts.

Qualitative and quantitative insights from the survey are summarised in Figure 5 in the form of general suggestions for building SPIs that encourage and enable ECR engagement. For example, boundary organizations and stakeholder groups like Open Network of IPBES Stakeholders (ONet) could host short online workshops for ECRs to complement the IPBES fellows programme. Young educators could embrace IPBES assessments, Sustainable Development Goals Reports (or similar science-policy works) as teaching tools to build interdisciplinarity capacities and science-policy training.

A key area of identified future work is in extending this survey to provide a more representative global view. This could be achieved through, for example, 1) the translation of the survey into a range of other

formats to ensure accessibility in languages aside from English and optimisation for ECRs using a range of assistive technologies including dictation, text to speech, etc., and/or 2) promoting wider distribution through a range of global networks and a longer data collection period.

Future work could focus on understanding the relationships between the participation of ECRs in SPIs, academic disciplinary background, and the degree to which ECRs participate in inter- and trans-disciplinary work. It could also seek to understand in more detail the impacts of various economic, practical, demographic factors determining participation in different global contexts (e.g. income, age, gender, etc.). Case study-based work exploring motivations, barriers, opportunities in those who already engage in SPI work, such as current and former IPBES Fellows or YESS delegations to IPBES, could be a route to increasing the depth and nuance of these insights. Furthermore, comparison of our findings with those from other initiatives (for example, the IPBES Stakeholder survey data that is to be published on Zenodo) could generate useful insights and serve as inspiration for future investigations.

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ORCID

Anna Filyushkina http://orcid.org/0000-0002-3586-2028
Andrew N. Kadykalo http://orcid.org/0000-0002-7359-0967
C. Sylvie Campagne http://orcid.org/0000-0002-2566-7827
Carla-Leanne Washbourne http://orcid.org/0000-0001-7818-918X
Sophie Peter http://orcid.org/0000-0002-5262-6780
Paola Fontanella Pisa http://orcid.org/0000-0001-8462-0714
Giovanni Ávila-Flores http://orcid.org/0000-0003-0820-2638

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