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Concepts of Stakeholder Involvement in Science

Evidence from Sustainability Research

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Abstract This paper substantiates previous qualitative work on stakeholder involvement (SI) in science with evidence from practice. Through a web-based survey among scholars and researchers engaged with sustainability or transition research in Germany and internationally, current stakeholder involvement practices are systematically evaluated. The underlying framework consists of five criteria that are crucial for a scientist's perspective on stakeholder involvement: *understanding of science, kind of knowledge, objectives, roles and the science-policy-interface.*Building on these criteria, four ideal types of SI in science are derived: the technocratic, the neoliberal-rational, the functionalist and the democratic type [43]. Based on this conceptual work, we strive to answer the following four research questions: In what way do scientists involve stakeholders today? What kind of concepts and ideals underlie their actions? Do ideals and reality match when scientists involve stakeholders? How do researchers' concepts of and ideals concerning stakeholder involvement relate to the types of SI identified in our previous research? Our results (n=52) give an interesting overview about different backgrounds and types of stakeholder involvement in science. Even though most respondents do not see a clear gap between their concepts of SI and their experience when conducting it, they stated manifold problems and trade-offs. Although there was agreement on some of the criteria for SI, the data did not reflect consistent types of SI as defined in our framework (see [43]). This might be a hint towards a lack of training and reflection of practitioners towards conceptual and theoretical questions of (transdisciplinary) science. We conclude that more qualitative research on actual practices is needed to better understand the stakeholder-scientist nexus.

Keywords Concepts of Stakeholder Involvement · Sustainability Research

1 Introduction: Understanding Practices of Stakeholder Involvement in Science

The involvement of stakeholders in science is an expanding trend in an increasing number of research areas, especially in those which besides their technological dimension touch societal, economic and political interests [1]. Due to the societal embeddedness and complexity of such fields like i.e. the energy transition, the scientific community felt the need to go beyond conventional scientific methods by incorporating non-academic actors' views and knowledge in their research. These actors are commonly addressed as "stakeholders", e.g. as "persons that, besides their expertise, also have an interest in some aspect of reality because they are a part of it. Stakeholders can be representatives of associations, companies or non-governmental organizations" [48].

Thus, the concept of stakeholder involvement, which has been common in the economic realm (mainly to deal with Corporate Social Responsibility strategies) or the political realm (i.e. in decision-making processes) for some time, has also been integrated into the broader science environment [67: 175-178]. It is especially prominent in new emerging scientific fields such as sustainability science[1] [33,8,36,28,52,30,74], transformative research [63,71,11,9] and transition research [34,18,19,39,42]. These new fields incorporate a broad array of concepts

[1] For a comprehensive and thorough review, see [37].

like post-normal-science [17], mode-2 science [20], mode-3 science [63] or citizen science [27,14] as well as transdisciplinary [26,4,10,65,5,29,49] and participatory research strategies [31,32,3,61,64,22,60].

Since stakeholder involvement in science is a relatively recent trend, academic literature mainly focuses on specific case studies [7] and there is yet little work on comprehensive frameworks and concepts that help differentiate between the various ways SI is practiced in science. Drawing on the work of Renn and Schweizer [59] on stakeholder and public involvement in the political realm of risk governance, we have addressed this conceptual research gap by developing ideal types of SI in our previous work [43]. We used the categories of roles, objectives, understanding of science, kind of knowledge and science-policy interface to develop four ideal types of stakeholder involvement in science.[2] Here, we strive to answer the following four research questions:

1. In what way do scientists involve stakeholders today?
2. What kind of concepts and ideals underlie their actions?
3. Do ideals and reality match when scientists involve stakeholders?
4. How do researchers' concepts of and ideals concerning stakeholder involvement relate to the types of SI identified in our previous research?

We have developed an online survey for practitioners of SI in sustainability science that we have distributed through our networks using a snowball sampling procedure. The survey aims at gathering information on current practices of stakeholder involvement in science as well as at systematizing the researchers' underlying concepts. Thus, we ask for information on demographic criteria such as education, funding and current projects as well as on the methods and kinds of stakeholders involved. Aside from data on scientific fields and researcher profiles, the survey focuses on conceptual questions, asking for the scientists' ideals when involving stakeholders. In this context, we draw on our five criteria of stakeholder involvement in science: which *understanding of science* is guiding scientists in their research? What *roles* do scientists assign to stakeholders? What are the scientists' *objectives* when involving stakeholders? What *kind of knowledge* do they want to gather and (how) is this knowledge relevant in the *political realm*? For each question, we offer four idealtypical answers that each reflect a certain understanding of stakeholder involvement as identified in our typology. Thus, the survey also provides information on how our ideal-typical positions on SI reflect the actual understanding of practicing scholars. Furthermore, we have asked scholars whether their ideals of SI match their actual experiences in the field and whether they see any trade-offs between their scientific goals and stakeholder involvement. Finally, the survey looks ahead, addressing the question of necessary improvements that would allow scientists to integrate stakeholders better in the future.

The paper proceeds as follows: Section 2 shortly reiterates our conceptual framework, i.e. the five criteria of stakeholder involvement in science that guide our analysis and the four ideal-types of stakeholder involvement we derived from them. In Section 3, we present the survey questions in more detail and describe how we have operationalized the theoretical framework for our questions on concepts (see Table 1). Moreover, we give information on the kind of data we have collected. In Section 4, we present and evaluate the responses, looking at researcher profiles and current practices (4.1), underlying concepts of SI that guide these practices (4.2), a comparison of ideals and actual experiences in the field (4.3), possible improvements mentioned by respondents (4.4) and attempting a first conceptualization of practices by relating the respective answers to our typology (4.5). In Section 5, we discuss our results and give further recommendations for research and practices. Section 6 concludes with a short summary and an outlook on further research steps.

[2] Parts of this working paper were taken from the original paper that describes the typology [43]). In this paper, we want to use this conceptual framework to take a wider empirical look at stakeholder involvement in scientific research projects.

2 A Framework for Different Concepts of Stakeholder Involvement in Science

To systematize different aspects of the theoretical approach of scientists regarding stakeholder involvement, we developed five criteria of differentiation:

1. *Role of the scientist:* The perception on which role the scientist should take (and in relation to that also the stakeholder) differs widely. This also relates to the question of the autonomy of science (see for example [73]: 180).[3] Adding to the role, we also looked into the *stages* of the research process where stakeholders are involved.
2. *Objectives*[4]: The reasons why a scientist would want to work with stakeholders are diverse—ranging from increasing impact on real world issues to getting insider information or increasing legitimacy (see for example [59]: 176).[5] Also, we ask for the main *reason* for involving stakeholders in the different stages of the research process.
3. *Kind of knowledge:* Scientists seek to gather different kinds of knowledge when involving stakeholders. Based on other differentiations such as cognitive, experiential and political knowledge ([21]: 301f) or system, orientation as well as target-and transformation knowledge ([63]: 42ff, 69ff), we structure the kinds of knowledge[6] that scientists can integrate into their research along the range of pure data, information, assessments and normative values.[7]
4. *Understanding of science:* Scientists have different understandings of good or appropriate science concerning tools and methods, epistemic and ontological questions ([72]: 53ff). Is science a detached system dealing with self-referential questions or does science serve societal needs? Can science be neutral and objective or does it mirror societal developments and conflicts?
5. *Science-policy-interface:* The role and impact scientist have – or expect to have – on political decision-making, and hence their perceptions of the societal responsibility of science, strongly imply how stakeholders are involved in the research process.

The above-mentioned criteria show that there can be different perspectives on Stakeholder Involvement in science. Systematizing these different perspectives, we have developed four ideal types of SI according to the position they take regarding these five criteria: the technocratic, neoliberal-rational, functionalist and democratic type. Depending on the perspective a scientist takes, actual stakeholder involvement practices and the difficulties and critical choices they entail can differ substantially. The types and their respective position on the five criteria will only be briefly sketched here. For a more detailed description, see [43].

The *technocratic type's* main objective when involving 'expert-stakeholders' ([23]; [117]: 5) is to improve the scientific research process by broadening the extent of available information. The role of the stakeholder is to provide issue-specific, objective and falsifiable information that fits into the classical way science is conducted according to philosophers of science such as Popper [55]. If lay people are involved in research processes, it is only indirectly as a source of data ([12]: 293f). They do not provide information themselves – e.g. the interpretation of this data – but lend it to scientists who then use it to extract what they consider is relevant for their research ([12]: 298f, [13]: 227). Scientists determine all the elements of the research process autonomously. Consequently, the scientific sovereignty of

[3] Welp et al. ([73]: 174f) distinguish the different types of stakeholder participation in science via their roles in the research process.

[4] For a better understanding, we used the term „goals“ in the questionnaire rather than objectives.

[5] Renn and Schweitzer [59] have developed a typology based on the different views and their objectives concerning stakeholder involvement in decision-making processes.

[6] Since there is a broad community that critically assesses scientific knowledge or what is perceived as it, we acknowledge this criticism, but refer to the kinds of knowledge in relation to the understanding of science of the different types of researchers.

[7] See also the discussion in Foucaults "Two Lectures on Power/Knowledge" ([15]:81) where he differentiates erudite and subjugated knowledges, the latter described as "naive knowledges; located down on the hierarchy, beneath the required level of cognition or scientificity".

interpretation, or the primacy of science, is kept. The kind of knowledge that is to be generated by stakeholder involvement is defined from a purely scientific angle. Thus, research questions are derived from intra-scientific debates and controversies. The understanding of the science-policy interface is often circumscribed by the idea of "speaking truth to power" ([54]: 10f). Scientific findings are expected to inform policy processes, but are not actively promoted by the scientist.

The *neoliberal-rational type* understands knowledge as "merely a 'hook' on which interests hang their case" ([57]: 173). The objective to involve stakeholders is to efficiently obtain data or knowledge and to channel results into projects and decision-making processes to ensure impact or application of the research. Stakeholders – such as lobby groups or individuals[8] advocating for their organizational, individual or political interests – try to channel their views directly into the research process and indirectly into a public discourse or the political arena. Furthermore, stakeholders are interested in getting legitimacy for certain positions through the "objectivity"[9] attached to science ([69]: 297ff). The roles of scientists and stakeholders and their respective influence on the research process are not pre-defined in the "bargaining"[10] concept of stakeholder involvement. The kind of knowledge scientists try to derive is not bound to data or information, but can also include experiential and value-based knowledge like interests and opinions. As there are no general rules regarding which scientific reasoning and methods are appropriate, there is no single "right" way to do science. It depends on the actors' perceptions and constellations.

The *functionalist type* is based on an understanding of society as consisting of autonomous social spheres, or systems as introduced by Luhmann [40,35][11] and further developed with regards to social coordination processes [68,6,16,44,45]. From a functionalist perspective, stakeholder involvement has the objective to irritate the science system with other social perspectives and relevance criteria in order to trigger learning processes that can make science more sensitive for societal problems ([75]: 25, [76]: 333).[12] In order to generate occasions of irritation, functionalist scientists attempt to integrate 'representative stakeholders' of different societal logics, e.g. from the economic or political system. With regard to the understanding of science, this type suggests that the science system consists of all communication that observes the world through the lens of truth.[13] Because the kind of knowledge that stakeholders provide is always related to their respective mode of observation, these observations are merely 'noise' or unspecified communication that does not (yet) make sense in scientific terms. Since science and politics do not share a common interface of integration in this perspective, stakeholder involvement can only be a tool to enhance the probability that self-reflective processes are triggered.

For the *democratic type*, stakeholder involvement – often realised as "dialogues" – has the objective to integrate societal actors that are part of a societal transformation or sustainability matters ([70]: 232ff; [63]: 314ff) into the research process, thus allowing "for the development of a genuine and effective democratic element in the life of science" ([17]: 740f; [50];[41]). From a democratic viewpoint, extending stakeholder dialogues from experts and

[8] In this context, it is important to note that stakeholders are not themselves the object of study. Instead, a stakeholder accompanies the research process in some way or other (for a similar understanding see [48]: 12f).

[9] See also the argument of the "scientific seal of approval" used by policymakers as put forward by Yosie and Herbst ([77]: 40).

[10] These ontological foundations relate to basic assumptions of game theory ([47]: 155).

[11] We base our discussions on Luhmann's systems theory, because his skepticism of social steering provides an interesting starting point for thinking about stakeholder involvement. We thus do not include other prominent systems theoretical approaches in this paper (see e.g. [58;53]).

[12] Mölders describes this probabilistic perception of coordination which is characteristic for the functionalist view as a "causality of triggering". It is differentiated from a "causality of penetration" that informs most perspectives on governance ([46]:3).

[13] Accordingly, the economic system is defined by all communications that deal with the question of whether payments can be generated or not. The political system observes the world from the criterion of whether a certain event is relevant for power (gain or loss), which in democratic societies is qualified by the binary distinction of government/opposition.

scientists to civil society can enhance the quality of the research results ([66]: 283). Instead of only data and scientific observations, subjective probabilities, science- and knowledge-based opinions or networks are integrated. By opening all stages of the research process to stakeholders, e.g. from the definition of the research questions ("Co-Design", [63]: 121ff, 182, 211, 314ff) to answering them ("Co-Production"), socially robust knowledge is created ([51]: 166). Hence, stakeholder involvement is seen as a means to improve the interconnection and exchange between science and politics. The scientist's role is to facilitate and moderate the dialogue on eye-level [25], bringing together different stakeholders from politics, business, research and civil society in an open arena[14]. This underlines the idea that the democratic type understands science as a tool to support transformation in society.[15]

3 Methods: Operationalization and Data Collection

To answer our research questions, we developed an online survey with the tool Survey Monkey that posed 30 questions of varying types. The survey consists of four parts: demographic data, information on stakeholder projects, concepts of stakeholder involvement, and looking ahead on possible improvements for stakeholder involvement. We will briefly describe each section separately:

The first set of questions from 1 to 7 covered the *demographics*, namely gender, nationality, level, kind and field of education and place of work. All questions except for age and nationality were closed, but allowing to add additional information via the category "Other". Question 6 on the field of education allowed multiple answers. These questions were followed by a range of queries on the *stakeholder projects* the respondents carry out; addressing how often stakeholders were involved (Q8), the nature (Q9), topics (Q11), funding (Q12), and regional level (Q14) of projects, the kind of stakeholders involved (Q10) and methods used (Q13) as well as stages of the research process in which stakeholders are involved (15). Multiple answers were allowed for most questions.

To get a better impression on the different concepts of SI that scientists have in mind when involving stakeholders in their scientific projects, we asked for an evaluation of different statements based on our conceptual framework described in section 2. The questions relate to the five criteria for stakeholder involvement, whereas the four possible answers reflect the four ideal types of stakeholder involvement. The respondents were asked to judge the answers according to a 5-item scale ranging from totally agree (5) to totally disagree (1): Why stakeholders are involved in certain stages (Q16), what the main goal of the scientist should be (Q19), what the science-policy interface should look like (Q20) and the understanding of science (Q21). Two questions, on the main role the scientist should play in SI-projects related to the role of the stakeholder (Q17) and on the kind of knowledge (Q18), allowed only to choose one of the four statements without grading them. Questions 17,18 and 20 were then each accompanied by an open question concerning the respondents' actual experiences in their projects. Table 1 summarizes how we have operationalized each of the five criteria and the respective ideal-typical answers from which the respondents could choose:

[14] This relates to the concept of the transition arena of Rotmans [62] and Loorbach [38].

[15] In this paper, we explicitly deal with the involvement of stakeholders in science and not in participatory or decision-making processes.

Table 1 Operationalization of Ideal Types

	Technocratic Type	Neoliberal-rational Type	Functionalist Type	Democratic Type
Stage (Q15)	Data collection	Data collection/ Planning phase/ Analysis of results/ Dissemination	Data collection	Data collection/ Planning phase/ Analysis of results/ Dissemination
Reason for Stage (Q16)	To increase the extent and quality of data by consulting issue-specific experts	To find out about stakeholders' interests and feed them into the research process	To test research findings against their perception and practicality in societal spheres	To allow stakeholders affected by the research to give feed-back and join deliberative processes
Role (Q17)	Scientist (S) leads the research process. Stakeholders (SH) are considered issue-specific experts.	Scientist (S) is a stakeholder (SH) himself and bargains for his or her (scientific) interests in the research process.	Scientist (S) observes only from an external position to analyse the perspectives of stakeholders (SH)	Scientist (S) facilitates and moderates a cooperative dialogue with affected stakeholders (SH), trying to create trust.
Kind of Knowledge (Q18)	Objective data and information concerning technologies or scientific problems	Networks and interests of stakeholders	System-specific perspectives and languages	Needs and values of the stakeholders involved
Objective/Goal (Q19)	get better data by involving issue-specific experts	increase relevance, ensure funding and impact of his research	understand learning processes in science and society	integrate the perspectives of all actors touched by societal transformations
Science-policy-interface (Q20)	Science and policy making should be two separate fields. Policy makers can use the results of scientists.	Through the integration of different interests, science can sketch out different paths or courses of action for policy makers.	Scientific findings cannot directly be integrated into political decision-making processes but have to be translated by the scientist into information that is useful for policy makers.	Science should address the gap between science and society, thus contributing to well-informed, democratically justifiable decisions.
Understanding of Science (Q21)	It should be autonomous, ethically neutral and objective.	It always depends on perceptions and constellations of the actors that carry it out.	It is the societal sphere in which true statements are differentiated from false statements.	It should address societal needs and thus support societal transformations.

In the fourth part of the survey, we wanted to look ahead on SI in science. Thus, we asked for improvements of stakeholder involvement (Q23; multiple choices allowed), for the future use of stakeholders in projects (Q24) and possible trade-offs between scientific goals and stakeholder involvement as an open question (Q25). In the last part of the survey, we collected feedback on the questionnaire and contact information of the participants (Q26-30). The data we have collected mostly concerns qualitative characteristics such as gender, field of education or kind of funding, which is of a *nominal scale of measurement.* In order to give our respondents the opportunity to bring in their own concepts, we also employed an open 'other'-category for most closed questions that we also include in our analysis. When we asked for the respondents' actual experiences with SI in science, we used open questions where they could express themselves in their own words. Table 2 summarizes the different types of data according to their respective scale of measurement.

Table 2 Types of Data Collected in the Survey

Scale	Characteristics Queried
Nominal (closed questions)	*Demographics*: Gender; Nationality; level, kind and field of education; place of work; *SI-projects*: kinds, topics and level of projects; kinds of stakeholders (SH), kinds of funding, methods, stages of research process in which SH are involved; (age) *SI-concepts*: role the scientist (S) should play in SI-projects; kind of knowledge that should be gathered in SI; improvements needed in SI
Nominal (open questions)	'Other'-categories for most closed questions *Actual experiences with SI-projects*: role of the S and the SH, kind of knowledge gathered, science-policy interface *Looking ahead on SI*: What is needed to improve SI in the future; possible trade-offs between scientific goals and SI
Ordinal	*SI-projects*: How often are SH involved (never; seldom; regularly; all the time); future involvement of SH (less, same, more); *SI concepts:* Agreement or disagreement to different conceptualizations of SI in science; we offered 4 statements concerning the criteria of objectives (19), role of S and SH (16), the science-policy interface (20) and the understanding of science (21). The respondents could judge these statements according to a 5-item scale ranging from totally agree to totally disagree *Looking ahead on SI:* How often will Stakeholders be involved in the future?

To reach our respondents, we used a snowball sampling technique [24; 56: 184] by accessing scientists connected with us in a first step. We then asked these scientists to pass on our survey within their networks. Also, we accessed whole networks of sustainability scientists ourselves. The contacts included were from: the Potsdam Institute for Climate Impact Research (PIK), the Mercator Research Institute on Global Commons and Climate Change (MCC), the Global Climate Forum (GCF), the Förderschwerpunkt Sozialökologische Forschung (SÖF), the Institute for Advanced Sustainability Studies (IASS), an Energy Market Network for Germany (Strommarkt-Verteiler), Germanwatch, the Mercator Foundation, the German Institute for Economic Research (DIW), the Böll-Foundation, the National Aeronautics and Space Research Centre of the Federal Republic of Germany (DLR), the Institute for Ecological Economy Research (IÖW), the Helmholtz-Centre for

Environmental Research GmbH – UFZ, the University of Bielefeld, the University of Hamburg, the Eberswalde University for Sustainable Development, University of Mainz, Freie Universität Berlin, TU Berlin, Leuphana University, Fraunhofer ISI and the Research Center for Interdisciplinary Risk and Innovation Studies of the University of Stuttgart.The survey was online from July 7th to August 25 2016 and was closed after 89 responses. This working paper is preliminary since it includes only an analysis of the first 52 responses.

4 Results: Ideals, Experiences and Future Prospects of Stakeholder Involvement in Science

In order to get a first impression on the current practices in stakeholder involvement in science, we mostly use absolute and relative frequencies for our nominal data as well as qualitative interpretation for our open questions.[16] Furthermore, we employ contingency analysis [2] as a multivariate statistical method, using the software package SPSS, to investigate the scientists' positions on different criteria of SI and the kinds of concepts they pursue. We will take three steps in presenting our results.

First, we give an overview on the current practices in SI as presented in our sample. This entails information on the scientific fields in which SI is currently practiced, the scholars and institutions which carry out or finance the research and the methods and tools applied (4.1). We thereby address the first research question: In what way do scientists involve stakeholders today?

Second, we describe how our respondents have positioned themselves concerning different concepts and ideals of SI in science along the five criteria we have introduced (4.2). Additionally, we will summarize the information gathered on the experiences scholars made when carrying out their research projects. In this context, we will focus on two aspects: We will evaluate whether the scientists' experiences are in line with their concepts and ideals of SI (4.3) and we will discuss the kinds of measures scientists' perceive necessary to improve the way SI is practiced in science (4.4). This helps us to answer the second and third research question: What kind of concepts and ideals underlie the scientists' actions? And do ideals and reality match when scientists involve stakeholders?

Third, we will relate the respondents' judgements to our typology of SI in science, testing for positive connections among the answers to different criteria that reflect a certain type (4.5). Thus, we try to answer the fourth research question: How do the researchers' concepts and ideals relate to the types identified in our previous research?

4.1 Current Practices

Most participants were male (66%), most are holding a Master or PhD (40 and 38% respectively). Our sample has strong interdisciplinary background (72%). Most participants come from social sciences (58%) and explicitly marked interdisciplinary fields like sustainability science (38%). While the vast majority of scholars are German, we also reached scholars from other countries like Spain, Italy, Greece, Denmark and France as well as China, Ghana and Iran. Participants work mostly at research institutes (38%) and universities (34%) or consultancies (15%). Especially scholars from universities and research institutes show a high degree of stakeholder involvement (75% and 81% respectively). Overall, 66% of the respondest involve stakeholders regularly (66%); for the majority in a transdisciplinary (52%) or interdisciplinary (43%) manner. The stakeholders involved come from a broad spectrum, with politics at the forefront (85%), followed by civil society (74%) as well as companies and science (65% each). Citizens rank last with 51%.

The main research topics our respondents deal with are energy (55%) and climate policy (42%)[17] and funding comes mainly from national governments and European institutions

[16] We also ask for the age of our respondents, which we treat here as a qualitative characteristic.

[17] This was expected since our sample contains mostly responses from sustainability researchers.

Fig. 1 Frequencies on question 10: "I work with stakeholders from: science, politics, companies, civil society, citizens, other". Multiple answers were allowed.

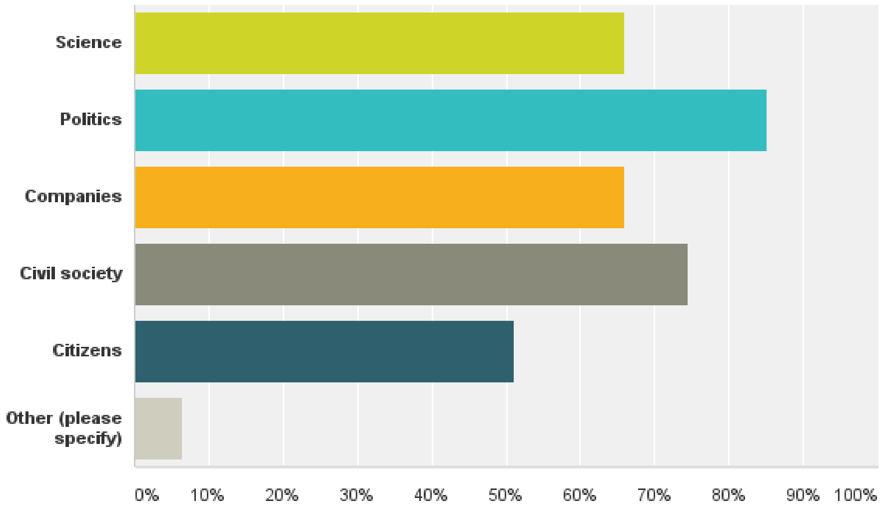
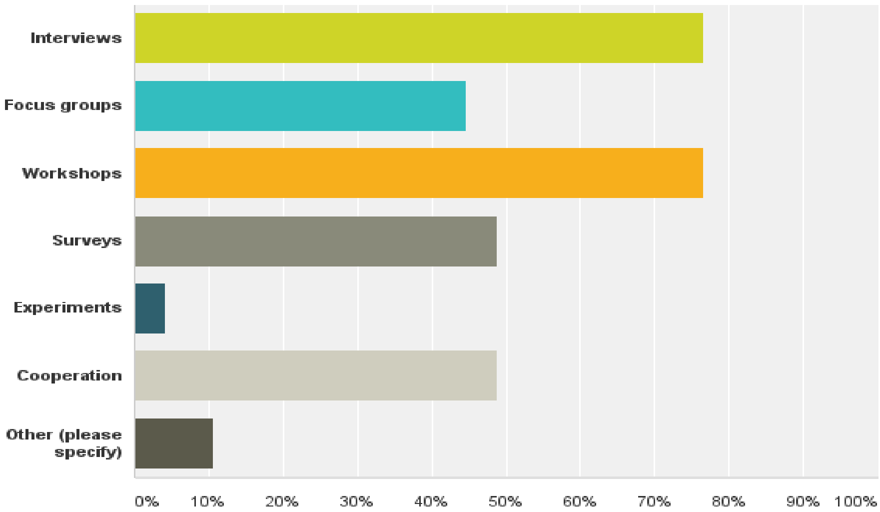


Fig. 2 Frequencies on question 13: "I involve stakeholder mostly through..." Multiple answers were allowed.



(40%) or foundations (25%). Out of those respondents that get funding from national government or companies, two thirds also work on energy topics. Companies don't seem to invest into climate policy research, which is prominent among public funders: 41.4% – 47.4% of those respondents that are funded by public institutions also work on climate policy issues.

With regards to methodology, interviews and workshops are more frequent (76% each), with surveys, focus groups and cooperation on a second level (40%).The methods used are independent from the kinds of stakeholders involved. Experiments are not a preferred method for SI. Especially in research institutes, workshops are highly common (90.5%). In universities, in contrast, only 64% of the respondents facilitate workshops. The level at which SI is used is primarily national(68%),the local level ranks second with 49%. Regional and international levels are less common (38% and 30% respectively).

4.2 Underlying Ideals

In order to investigate the underlying ideals that guide scientists when involving stakeholders in their research, we have asked the respondents to grade four possible positions on the different criteria of SI: What is the main goal of stakeholder involvement and in which stages of the research process is it especially important to involve stakeholders? What are the respective roles of the scientist and the stakeholder? What kind of knowledge is to be gathered? What should the science-policy interface look like and what is the scientists understanding of science? In this section, we summarize the respondents' views on each of these criteria.

Main Goal of Stakeholder Involvement and Stages of the Research Process

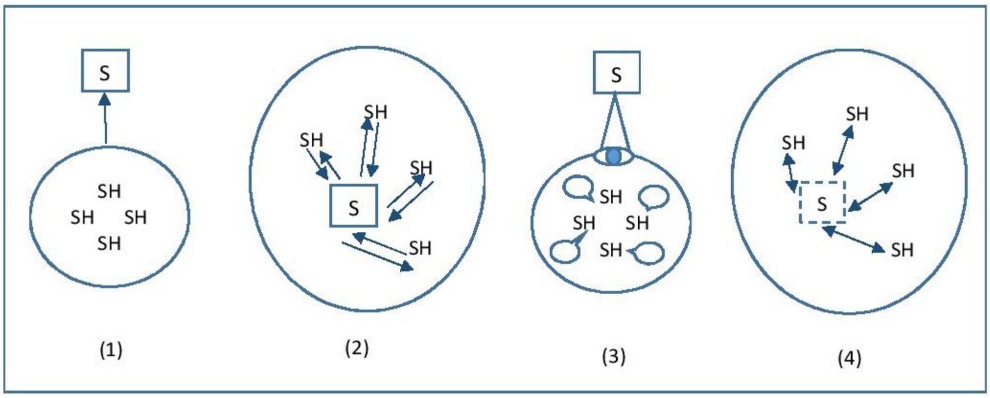
The question on the main goal of stakeholder involvement allowed to grade four choices according to a 1-5 item scale, ranging from strongly agree (5) to strongly disagree (1). In the following, we assemble grades of 1 and 2, understanding them as 'disagreement' and the grades of 4 and 5 as agreement. When speaking of strong agreement, we refer to grade 5 (with strong disagreement being grade 1 respectively). The highest agreement could be found for the position that the scientist mainly involves stakeholders to "increase relevance, ensure funding and impact of his research" (86%). Slightly more than three fourths of the respondents agreed to getting "better data by involving issue-specific experts" as a main goal, as well as three fourths wanting to "integrate the perspectives of all actors touched by societal transformations". The position to "understand learning processes in science and society" was agreed on by 70% of the respondents. Interestingly, no one strongly disagreed with any of the statements. The aim to get better data had no disagreement at all. 10 percent of the sample strongly agreed to all four statements. When asked in which stages of the research process stakeholders should be involved – where multiple options could be selected – data collection (91%) was the option most respondents chose, followed by the planning phase (83%) and dissemination (80%). Still, around 57% said they would involve stakeholders in the data analysis. Roughly half of all respondents want to involve stakeholders in all stages of the research process. When asked why they want to involve stakeholders at a certain stage of the research process, respondents were allowed to evaluate four different choices of answers. 83% agreed to the statement "To find out about stakeholders' interests and feed them into the research process", just as 83% want to "increase the extent and quality of data by consulting issue-specific experts". The strongest disagreement could be found for the statement "to allow stakeholders affected by the research to give feed-back and join deliberative processes" with 16% disagreeing. The strongest motivation was to find out about stakeholders' interests, where 54% strongly agreed.

Role of Scientist and Stakeholder

Regarding the scientist's main role, respondents had to select one of the four choices. The role of the scientist as facilitating a dialogue (30%)[18] was the most often chosen answer, followed by the idea of the scientist being a stakeholder bargaining for his interest (27%). 23% of the respondents see the scientist as the leader of the process, while a fifth think the scientist should be an external observer. This shows a wide divergence of specific roles in SI practices. Since only one answer was allowed, we can relate the different answers to our types, showing that the respondents quite evenly distributed their choices, with a slight preference for the democratic type's understanding of roles in the research process, whereas the functionalist perspective was the least picked (20%). The different roles are illustrated in Figure 3.

[18] The percentages relate to the number of persons that have responded to each answer choice. There are minimal differences within one question (e.g. 41 respondents for answer 1, 40 for answer 2.)

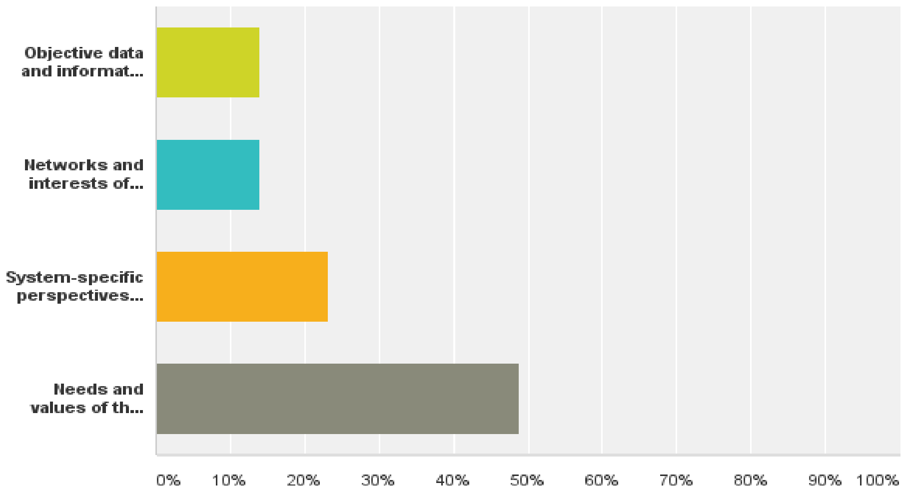
Fig. 3 Role of Scientist (S) and Stakeholder (SH) in the research process. Legend: (1) S leads the research process, SH are considered issue-specific experts; (2) S is a SH himself and bargains for his or her (scientific) interests in the research process; (3) S observes only from an external position to analyse the perspectives of SH; (4) S facilitates and moderates a cooperative dialogue with affected SH, trying to create trust.



Kind of Knowledge

The kind of knowledge that is produced in stakeholder involvement processes is a highly contested issue. Nevertheless, the responses were clearly leaning towards finding out about needs and values of stakeholders (49%) which we attribute to the democratic type, followed by system-specific perspectives and languages (23%) attributed to the functionalist type.

Fig. 4 Frequencies on question 18: "According to your understanding of stakeholder involvement in your scientific field: what kind of knowledge **should** be mainly produced in stakeholder projects?



When looking at the respondents' educational background, it shows that the democratic position on the kind of knowledge got the highest percentage of agreement among natural scientists – out of which 70% chose this option – and the scholars with an interdisciplinary background such as sustainability science, where 65% chose the democratic option. While around 45% of the engineers and social scientists also said that they are mainly looking for the democratic kind of knowledge, the functionalist kind of knowledge was also quite popular among social scientists (31%), while one third of the engineers find the neoliberal-rational kind of knowledge most important (33%). Among the natural scientists, the technocratic, neoliberal-rational and functionalist positions were shared equally by 10% of the respondents, whereas scholars with an interdisciplinary background favor the neoliberal-rational kind of knowledge least (6% of the interdisciplinary respondents chose this option), followed by the technocratic (12%) and the functionalist (18%) option.

Science-Policy Interface

The perception that science should "address the gap between science and society, thus contributing to well-informed, democratically justifiable decisions" was by a slight number the most agreed answer concerning the science-policy interface in our survey. 81% of the respondents agreed or strongly agreed. 80% also agreed that "through the integration of different interests, science can sketch out different paths or courses of action for policy makers". In both cases, none of the respondents strongly disagreed with the statements. That science and policy making should be two separate fields – this view can be attributed to our technocratic type – was the least popular position with only 30% of agreement and 49% of disagreement, but also a high level of indifference (22%). 63% agreed or strongly agreed with the functionalist perspective, that "scientific findings cannot directly be integrated into political decision-making processes but have to be translated by the scientist into information that is useful for policy makers". A fifth of the respondents were indifferent to this position.

Understanding of Science

The vast majority of respondents agreed or strongly agreed with what we framed as the democratic type's understanding of science (79%), stating that science "should address societal needs and thus support societal transformations". None of the respondents strongly disagreed with this. The most contested statement was the functionalist type's perspective: 37% of the scientists disagreed or strongly disagreed that "science is the societal sphere in which true statements are differentiated from false statements". Also, almost 50 percent were indifferent to this position. 63 percent of the respondents agreed or strongly agreed with the neoliberal-rational type's position that science "always depends on perceptions and constellations of the actors that carry it out". 60% think that "science should be autonomous, ethically neutral and objective". Looking at the individual answers, only two people agreed to all statements. 13 respondents agreed or strongly agreed to the two statements that lie close together, that science "should address societal needs and thus support societal transformations" and that science "always depends on perceptions and constellations of the actors that carry it out". At the same time, they rejected the two positions that take a very different perspective (disagree, strongly disagree or neutral), namely that "science is the societal sphere in which true statements are differentiated from false statements" and "science should be autonomous, ethically neutral and objective".

4.3 Contrasting Ideals and Experiences

When we asked for the scientists' judgements on what roles scientists and stakeholders should have in the research process, on the kind of knowledge that should be produced and how science and policy-making should be related, we also gave the opportunity to compare ideals with practical experiences. The following sections points to interesting statements on these three issues:

Role of Scientist and Stakeholder

Most scientists do not see a mismatch between their concept of the relationship between scientists and stakeholders and their experience in past projects. Some respondents pointed to the fact that, depending on the project and the research question, the roles can vary and thus the practice of stakeholder involvement is not something static. One scientist who considers himself a stakeholder as well and agreed to be bargaining for his/her scientific interest (neoliberal-rational type answer for question 17 on the roles) reported on the difficulties to accept these new roles for scientists: *"The challenge for scientists is to accept the idea that they are not superior to the stakeholders."*

Kind of Knowledge

Concerning the knowledge that scientist actually gather in comparison to what they were hoping for, almost 20% of the respondents (n=10) stated that they found other kinds of knowledge than expected. Interestingly, this happened in various combinations, so that some were hoping to get objective data but instead got needs and values whereas others were looking for needs and values and got knowledge about networks and interests instead. However, the majority of respondents did not claim a difference in expected and actual kind of knowledge.

Science-policy Interface

When asked about the gap between expectations and experiences in the science-policy interface, eight respondents reported a mismatch. One scientist pointed to the learning process that researchers have to go through when involving stakeholders and using the knowledge to consult policy.*"It was a joint learning process. The idea that science can educate others unidirectionally is misleading."* Some respondents considered one option as closest to reality although they were thinking it *should* be otherwise. However, we could not find a general pattern as several combinations were mentioned.

Trade-offs between Scientific Goals and SI

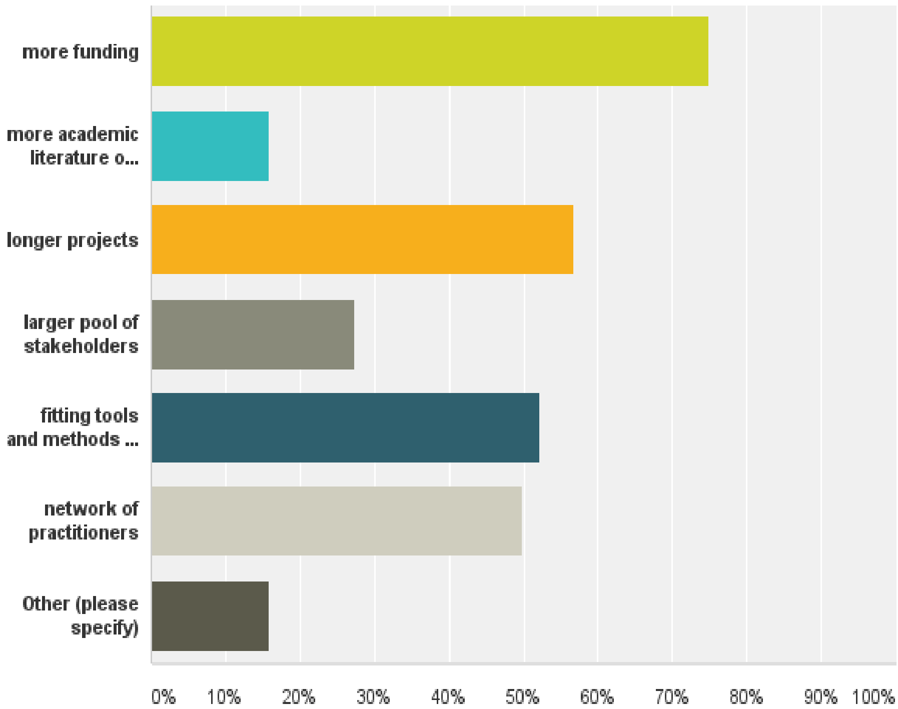
Concerning trade-offs between scientific goals and stakeholder involvement, 30 respondents acknowledged these, while 14 did not experience any trade-offs. Trade-offs can have very different character and reasons. Often (n=8) scientists pointed to time problems that lead to "*less time for peer-reviewed publications*", saying SI "*reduces written academic output*". This was weighted against the increase of relevance that might come with successful stakeholder engagement: "*(SI) increases – hopefully – the relevance and usefulness of that which is written (and thus also its academic quality)*." Besides the time resource factor, several respondents (n=8) see trade-offs between scientific goals and the interests of stakeholders more generally as "*the questions relevant to stakeholders do not always match the questions/ and or methods that are interesting from a purely academic position.*" One respondent states that when working with stakeholders, "*objectivity might be more difficult*". Thus, these respondents perceive that the autonomy of science can be questioned when involving stakeholders.

When compared to their understanding of science, those scientists who see the autonomy of science threatened often also agreed strongly to the understanding of science as something that "should be autonomous, ethically neutral and objective." When looking at contingency tables, we found some interesting connections among the two largest groups of respondents from universities (n=15) and research institutes (n=19). 80 per cent of the respondents working for universities see a trade off between their scientific goals and SI, whereas that holds true for 53% of the respondents from research institutes. Of those respondents who work in transdisciplinary projects (52%), the overwhelming majority (71%) see trade offs between their scientific goals and stakeholder involvement. 60 per cent of the people in interdisciplinary projects face the same problem.

4.4 Looking Ahead

In order to understand what scientists consider helpful to improve their work with stakeholders, we offered six ways in which this could be done: more funding, more academic literature on SI, longer projects, larger pools of SH, fitting tools and methods for SI, and a network of practitioners. The following chart gives an overview on the respondent's assessment.

Fig. 5 Frequencies on question 22: „What would you need to improve your work with stakeholders?"



Not surprisingly, most of the respondents (75%) think that more funding would improve the work with stakeholders. Also, longer projects, fitting tools and methods and a network of practitioners were seen as important elements of improvement. Overall, 15% of all respondents were seeking more academic literature on stakeholder involvement. Interestingly, only few respondents from university feel a need for more academic literature (6% of all university scholars), while one fourth of those employed in research institutes think more literature would be helpful. Also, two thirds (62%) of scholars from research institutes see a need for fitting existing tools and methods to stakeholder involvement in science, while only one third (35%) of university scholars share this opinion. Almost one third of all respondents want to work more frequently with stakeholders in the future, the majority wants to keep the level of involvement the same and only one respondent would like to integrate less stakeholders.

4.5 Conceptualization of Practices

To answer our fourth research question, we wanted to test whether it is possible to conceptualize the different understandings of stakeholder involvement in science that motivate practitioners to date. In particular, we checked whether we can trace patterns in the answers that reflect the ideal types from our typology.

In our questionnaire, we asked scientific researchers to position themselves regarding the five defining criteria in questions 16 to 21. For each question, we offered four choices designed to represent a view associated with one of our ideal types – option A for the technocratic, option B for the neoliberal-rational, option C for the functionalist, and option D for the democratic type (see table 2 for an overview). Thus, an *ideal*-typical democrat would choose option D for each of the six questions, while an *ideal*-typical neoliberal-rational would always 'agree' or 'strongly agree' with option B. However, these *ideal* types might not be reflected in the data since they are designed to serve as a heuristic tool to conceptualize debates on SI rather than offering an accurate empirical description of actual practices. In reality, of course, scientists may have multiple objectives for SI at the same time, they might have mixed conceptions that are not as clearly delineated as in theoretical debates and thus use 'hybrid' forms of SI. The latter hypothesis is supported by the data: In our contingency analysis, where we crossed all answering options with each other, looking for positive connections, we could not find a meaningful pattern regarding the four ideal-types of SI in science.

In question 17 on the role of the scientist and 18 on the kind of knowledge that scientists are looking for, respondents had to limit themselves to one choice – thus, they had to choose either the technocratic, neoliberal-rational, functionalist or democratic option. Except for the technocratic type, where we could find a significant positive association at the 10% level of significance (p-value of 0,066; phi-value: 0,255), there were no positive correlations among the types (and also not across types) for questions 17 and 18. Thus, the fact that a person takes a certain position on the role of the scientist in SI is statistically independent from that person's position on the kind of knowledge.

In the four questions where we asked scientists to express their agreement or disagreement to each of the four ideal-typical positions, this picture did not change. Many respondents agreed to three or more of the options offered, regarding their view of their motivation to involve stakeholders at a certain stage of the research process (16), their main objective (19), the design of the science-policy-interface (20), and their understanding of science (21). Especially concerning the contribution of the stakeholders and the scientist's main objective, the vast majority of scientists showed mixed conceptions: 69% and 63% agreed to three or four of the options offered. Table 3 summarizes this pattern:

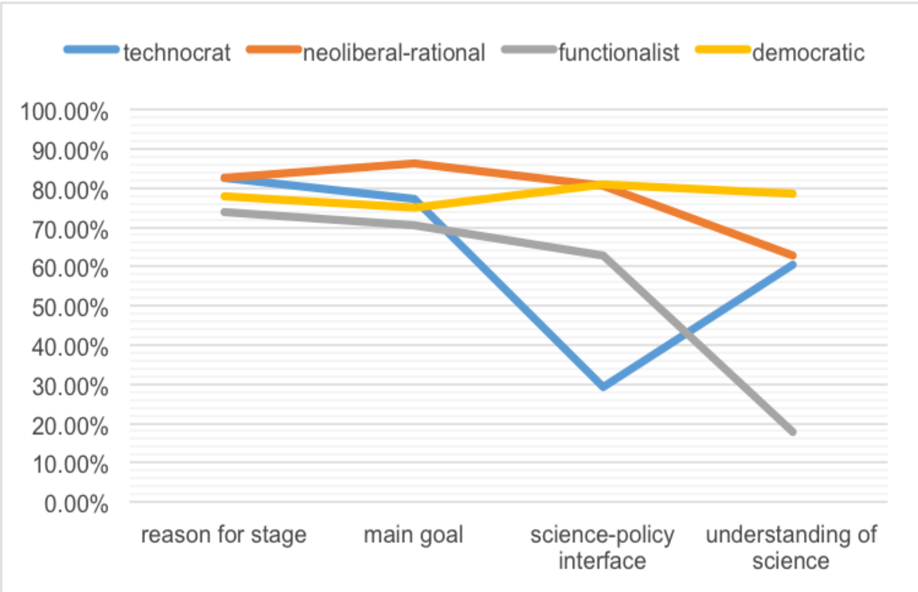
Table 3 Per cent of respondents who agreed to three or more options of questions 16, 19, 20 and 21.

Question	Topic	% of Respondents who strongly agreed or agreed to three or more of the options (absolute number)
16	scientist's motivation to involve stakeholders at a certain stage of the research process	69.2% (36)
19	scientist's main objective	63.5% (33)
20	scientist's understanding of science-policy interface	42.3% (22)
21	scientist's understanding of science	23.1% (12)

5 Discussion

As our results on the conceptual questions on SI show, respondents generally expressed a high level of agreement on the various positions we offered in the part of the survey that focused on concepts and ideals (Q16-Q21). On average, 62% of the respondents agree on the respective technocratic position, 78% on the democratic and neoliberal positions. Although the average agreement on the functionalist position is significantly lower, still over 56% of the respondents share the functionalist positions. Graph 1 shows the percentage of respondents that agreed or strongly agreed on the respective positions:

Fig. 6 Agreement of conceptual options (% of respondents who agreed (4) or strongly agreed (5) with the respective positions on SI in science)



While this result is in itself instructive, it also shows that our aim to find out about scientists' *main* positions and priorities was not reached. While we explicitly asked respondents to highlight the *most* important answer in each question, we did not want to limit their choices to one option for all the conceptual questions. Only in questions 17 and 18 they were forced to decide for one answer. For all other conceptual questions, we offered gradual assessments for each option in order to allow respondents to express their views in a more differentiated way[19]. We were hoping to achieve more interesting data, showing nuances and specific assessments.

The fact that we could not retrace clear conceptual prioritizations or even ideal types in the data might be explained in two different ways: On the one hand, respondents might have felt that all of the offered positions were more or less equally important so that they could not highlight the main reasons, goals or conceptualizations – despite our pledge to do so. This might inter alia be due to the fact that the answering options seemed not differentiated enough to the respondents. The same holds true for the consistency of our ideal types: they might be too abstract to be instructive on a practical level. Thus, the operationalization we offered in our survey might not be contrasting enough for practitioners to view them as different positions. This certainly explains part of our results.

[19] This was also a reaction to the feedback we got from our a pretest that was carried out to "test" the survey.

On the other hand, this result could also hint to a lack of conceptual clarity in current SI practices. As we have reiterated earlier, SI is a relatively recent trend and its underlying concepts and current practices might not yet be fully integrated. This interpretation is supported by the fact that some of the answering options scholars agreed to are, if not mutually exclusive, nevertheless reflecting very different concepts. In our view, these concepts can hardly be integrated into one consistent conceptual framework, as the respondents' answers seem to suggest. We illustrate this on the different positions we offered on how the science-policy interface should be designed: in the technocratic option, we highlighted that "science and policy-making should be two separate fields", whereas we formulated in the democratic position that science should play an active role in political decision making, addressing "[. . .] the gap between science and society, thus contributing to well-informed, democratically justifiable decisions". Though the neoliberal-rational position also sees science as actively involved in political decision-making processes, it does not highlight the enhanced legitimacy of decisions. Rather, in this view, science contributes to the "integration of interests" of the concerned stakeholders, which enables it to "sketch out different [. . .] courses of action for policy makers". In the functionalist perspective, the independence of science vis-à-vis politics is neither normatively affirmed (technocratic) nor rejected (neoliberal-rational, democratic). Rather, it is based on the idea that it can be hard to integrate scientific and political logic. This is why "scientific findings cannot directly be integrated into political decision-making processes but have to be translated [...] into information that is useful for policy makers". While we find that these options reflect quite different positions that can hardly be integrated into one consistent position on how the science-policy interface should be, 42% of all respondents have agreed to three or four of these options. In order to understand the implications of these answers, other qualitative criteria might have to be applied.

6 Conclusion

The findings presented in this working paper are a preliminary analysis of the data acquired in a survey among researchers that work in sustainability science. The partly confusing picture that was found through the analysis of the survey data which showed no clear conceptual prioritizations, underlines the need for conceptual tools for scientists that involve stakeholders. A heuristic conceptualization like the typology presented in Mielke et al. [43] can help to reflect on possible trade-offs before conducting the research and thus may help to resolve some of the conflicts scientists named in our survey, ranging from time conflicts ("more work for involvement, less work for scientific details", "less time for peer-reviewed publications", "time consuming",) over the possible loss of the autonomy of science ("some need nothing but legitimization by referring to science regardless of the content", "objectivity might be more difficult", "whenever stakeholders try to get the results they need instead of results that make sense") to quality conflicts concerning the results of the research ("Pay off between required scientific rigor to produce publishable results vs. assuring ownership and impact", "academic publications vs. relevant topics"). Thus, our paper tries to bridge the gap between the theoretical perspectives on stakeholder involvement and the practical implementation that becomes more and more common and desired in sustainability science. In a next step, we will use a cluster analysis to find patterns among the respondents' answers to our survey that could not be derived from our data with contingency analysis. Since there were many overlaps in our data, also on positions we thought to be mutually exclusive, further qualitative research, e.g. through interviews or focus groups, might be necessary to find out more about the respondents' motivations and problems when involving stakeholders in their scientific work.

References

[1] Action Research Manifesto, Action Research: Transforming the generation and application of knowledge (2011).

[2] K. Backhaus; Erichson, Bernd; Plinke, Wulff; Weiber, Rolf: Multivariate Analysemethoden. Eine anwendungsorientierte Einführung, 2008, Berlin: Springer.

[3] E. Becker, Problem transformations in transdisciplinary research, In: G. Hirsch Hadorn, (Ed), Unity of Knowledge in Transdisciplinary Research for Sustainability. Encyclopedia of Life Support Systems (EOLSS), 2006, Oxford: Publishers, Oxford.

[4] W. Berger, Methoden der Interdisziplinarität, In: W. Lenz, (Ed), Interidziplinäres. Wissenschaft im Wandel, 2010, Löcker; Wien.

[5] M. Bergmann, E. Schramm, Transdisziplinäre Forschung. Integrative Forschungsprozesse verstehen und bewerten, 2008, Frankfurt am Main/New York, Campus.

[6] A. Bora, Öffentliche Verwaltung zwischen Recht und Politik. Die Multireferentialität organisatorischer Kommunikation, In: V. Tacke, (Ed), Organisation und gesellschaftliche Differenzierung, 2001, Westdeutscher Verlag; Wiesbaden.

[7] P. Brandt, A. Ernst, F. Gralla, C. Luederitz, D.J. Lang, J. Newig, F. Reinert, D.J. Abson, H. Von Wehrden, A review of transdisciplinary research in sustainability science, Ecol. Econ. 92 (2013) 1–15.

[8] W.C. Clark and N.M. Dickson, Sustainability science. The emerging research program, Proc. Natl. Acad. Sci. U. S. A. 100, 2003, 8059–8061.

[9] D. Crocket, H. Downey, A.F. Fıratc, J.L. Ozanne and S. Pettigrew, Conceptualizing a transformative research agenda, J. Bus. Res. 66 (8), 2013, 1171–1178.

[10] A. Daschkeit, Interdisziplinarität und Umweltforschung, 1996, Zwischenbericht; Kiel.

[11] J. Dietz and J. Rogers, Meanings and policy implications of transformative research: frontiers, hot science, evolution, and investment risk, Minerva 40 (1), 2012, 21–44.

[12] D. Fiorino, Technical and democratic values in risk analysis, Risk Anal. 9 (3), 1989, 293–299.

[13] D. Fiorino, Citizen participation and environmental risk. A survey of institutional mechanisms science, Technol. Hum. Values 15 (2), 1990, 226–243.

[14] F. Fischer, Die Agenda der Elite. Amerikanische Think Tanks und die Strategien der Politikberatung, PROKLA 26 (3) (1996) 463–481.

[15] M. Foucault, Two lectures, In: C. Gordon and Michel Foucault, (Eds.), Power/Knowledge: Selected Interviews and Other Writings, 1972-1977, 1980, Harvester Press; Brighton UK, 78–109.

[16] P. Fuchs, Die Unbeeindruckbarkeit der Gesellschaft: Ein Essay zur Kritikabilität sozialer Systeme, In: M. Amstutz and A. Fischer-Lescano, (Eds.), Kritische Systemtheorie. Zur Evolution einer normativen Theorie, 2013, Transcript; Bielefeld, 99–110.

[17] S. Funtowicz and J. Ravetz, Science for the post-normal age, Futures 25 (7), 1993, 739–755.

[18] F. Geels, Technological transitions as evolutionary reconfiguration processes. A multi-level perspective and a case study Res. Policy 31 (8–9), 2002, 2157–2274.

[19] F. Geels, The sustainability transitions research network (SRTN), Environ. Innov. Soc. Trans. 1 (2), 2011, 192–194.

[20] M. Gibbons, C. Limoges, H. Nowotny, S. Schwartzman, P. Scott, M. Trow, The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies, Sage Publications, London, 1994.

[21] J. Glicken, Effective public involvement in public decisions, Sci. Commun. 20 (3), 1999, 298–327.

[22] J. Glicken, Getting stakeholder participation 'right': a discussion of participatory processes and possible pitfalls, Environ. Sci. Policy 3, 2000, 305–310.

[23] N. Gupta, A. Fischer, I. Van Der Lans and L. Frewer, Factors influencing societal response of nanotechnology. An expert stakeholder analysis, J. Nanopart. Res. 14, 2012, 1–15.

[24] Goodman, L.A. (1961). "Snowball sampling". *Annals of Mathematical Statistics*. 32 (1): 148–170.

[25] J. Habermas, Moral Consciousness and Communicative Action, 1990, MIT Press; Cambridge, Mass.

[26] G. Hirsch Hadorn, D. Bradley, C. Pohl, S. Rist and U. Wiesmann, Implications of transdisciplinarity for sustainability research, Ecol. Econ. 60, 2006, 119–128.

[27] A. Irwin, Citizen science, in: A Study of People, Expertise and Sustainable Development, Routledge, London, 1995.

[28] J. Jäger, The governance of science for sustainability, In: Adger W. N. and Jordan A, (Eds.), Governing Sustainability, 2009, Cambridge University Press; Cambridge, 142–158.

[29] T. Jahn, Transdisciplinarity in the practice of research, In: M. Bergmann and E. Schramm, (Eds.), Transdisziplinäre Forschung. Integrative Forschungsprozesse verstehen

und bewerten, 2008, Campus Verlag; Frankfurt/Main, 21–37.

[30] A. Jerneck, L. Olsson, B. Ness, S. Anderberg, M. Baier, E. Clark, T. Hickler, A. Hornborg, A. Kronsell, E. Lövbrand and J. Persson, Structuring sustainability science, Sustain. Sci. 6, 2011, 69–82.

[31] B. Kasemir, U. Dahinden, A. Swartling, D. Schibli, R. Schüle, D. Tabara and C. Jaeger, Collage processes and citizens' visions for the future, In: B. Kasemir, J. Jäger, C. Jaeger and M. Gardner, (Eds.), Public Participation in Sustainability Science, 2003, Cambridge University Press; Cambridge, 81–104.

[32] B. Kasemir, C.C. Jaeger and J. Jäger, Citizen participation in sustainability assessments, In: B. Kasemir, J. Jäger, C.C. Jaeger and M.T. Gardner, (Eds.), Public Participation in Sustainability Science, 2003, Cambridge University Press; Cambridge.

[33] R.W. Kates, W.C. Clark, R. Corell, J.M. Hall, C.C. Jaeger, I. Lowe, J.J. Mccarthy, H.J. Schellnhuber, B. Bolin, N.M. Dickson, S. Faucheux, G.C. Gallopin, A. Grubler, B. Huntley, J. Jager, N.S. Jodha, R.E. Kasperson, A. Mabogunje, P. Matson, H. Mooney, B. Moore, 3rd, T. O'riordan and U. Svedlin, Environment and development. Sustainability science, Science 292 (5517), 2001, 641–642, Available from: http://www.ncbi.nlm.nih.gov/pubmed/11330321.

[34] R. Kemp and J. Rotmans, Transitioning policy: co-production of a new strategic framework for energy innovation policy in the Netherlands, Policy Sciences. 42, 2009, 303–322.

[35] G. Kneer, A. Nassehi, Niklas Luhmanns Theorie sozialer Systeme, 2000, UTB/Wilhelm Fink, Paderborn.

[36] H. Komiyama and K. Takeuchi, Sustainability science. Building a new discipline, Sustain. Sci. 1 (1–6), 2006.

[37] D. Lang, A. Wiek, M. Bergmann, M. Stauffacher, P. Martens, P. Moll, M. Swilling and C. Thomas, Transdisciplinary research in sustainability science. Practice, principles, and challenges, Sustain. Sci. 7 (1), 2012, 25–43.

[38] D. Loorbach, Transition management governance for sustainability, Governance and Sustainability: New Challenges for the State, 2002, Business and Civil Society; Berlin.

[39] D. Loorbach, Transition management, New Mode of Governance for Sustainable Development, 2007, International Books; Utrecht.

[40] N. Luhmann, Soziale Systeme, Grundriss einer allgemeinen Theorie, 1984, Suhrkamp; Frankfurt am Main.

[41] S. Maasen and P. Weingart, Democratization of Expertise, 2005, Springer; Dordrecht.

[42] J. Markard, R.P.J.M. Raven and B. Truffer, Towards a research agenda on sustainability transitions: introduction paper to special section on sustainability transitions, Res.Policy 41, 2012, 955–967.

[43] J. Mielke, H. Vermaßen, S. Ellenbeck, B. Fernandez Milan, C. Jaeger, 2016,in: Energy Research & Social Science 17, 71-81.

[44] M. Mölders, Kluge Kombinationen. Zur Wiederaufnahme systemtheoretischer Steuerungskonzepte im Governance-Zeitalter, Z. Rechtssoziol. 33 (1), 2013, 5–30.

[45] M. Mölders, Irritation expertise. Recipient design as instrument for strategic reasoning, Eur. J. Futures Res. 2014, 15–32.

[46] M. Mölders, Publicity as a Medium of Intended Change. Towards a Concept of Irritation Design. Available from: http://www.unibielefeld.de/ soz/personen/moelders/Extended-Abstract-MM-140814.pdf (year not specified.)

[47] J.F. Nash, The bargaining problem, Econometrica 18 (2), 1950, 155–162.

[48] M. Niederberger and S. Wassermann, Methoden der Experten —und Stakeholdereinbindung in der sozialwissenschaftlichen Foschung, 2015, VS Verlag für Sozialwissenschaften; Wiesbaden.

[49] H. Nowotny, Transdisziplinäre Wissensproduktion —eine Antwort auf die Wissensexplosion?, In: F. Stadler, (Ed), Wissenschaft als Kultur, 1997, Springer; Berlin.

[50] H. Nowotny, Democratising expertise and socially robust knowledge, Sci. Public Policy 30 (3), 2003, 151–156.

[51] H. Nowotny, P. Scott and M. Gibbons, Re-thinking science, Knowledge and the Public in an Age of Uncertainty, 2001, Polity Press; Cambridge.

[52] E. Ostrom, A general framework for analyzing sustainability of social-ecological systems, Science 325 (July), 2009, 419–422.

[53] T. Parsons, The Social System, 1991, Routledge; London, (1951).

[54] C. Pohl and S. Stoll-Kleemann, Inter- und transdisziplinäre Forschung auf dem Prüfstand, In: C. Pohl and S. Stoll-Kleemann, (Eds.), Evaluation inter —und transdisziplinärer Forschung. Humanökologie und Nachhaltigkeitsforschung auf dem Prüfstand, 2007, Oekom Verlag; München, 7–22.

[55] K. Popper, Philosophy of science: a personal report, In: C.A. Mace, (Ed), British Philosophy in Mid-Century, 1957, Allen and Unwin; London.

[56] A. Przyborski and M.Wohlrab-Sahr: Qualitative Sozialforschung: ein Arbeitsbuch, 2014, Oldenbourg, München.

[57] C. Radaelli, The role of knowledge in the policy process, J. Eur. Public Policy 2 (2), 1995, 159–183.

[58] A. Radcliffe-Brown, On the concept of function in social science, Am.Anthropol. 37 (3) (1935) 394–402.

[59] O. Renn and P.-J. Schweizer, Inclusive risk governance: concepts and application to environmental policy making, Environ. Policy Governance 19 (3), 2009, 174–185.

[60] O. Renn, T. Webler and B.B. Johnson, Public participation in hazard management: the use of citizen panels in the US, Issues Health Safety 197, 1991, 197–226.

[61] J. Robinson and J. Tansey, Co-production: emergent properties and strong interactive social research. The Georgia basin futures project, Sci. Public Policy 33, 2006, 151–160.

[62] J. Rotmans, Transitiemanagement: Sleutel Voor Een Duurzame Samenleving, 2003, Koninklijke Van Gorcum; Assen.

[63] U. Schneidewind and M. Singer-Brodowski, Transformative Wissenschaft. Klimawandel im deutschen Wissenschafts—und Hochschulsystem, 2013, Metropolis-Verlag; Marburg.

[64] R. Scholz, D. Lang, A. Wiek, A. Walter and M. Stauffacher, Transdisciplinary case studies as a means of sustainability learning. Historical framework and theory, Int. J. Sustain. High. Educ. 7, 2006, 226–251.

[65] R.W. Scholz, Mutual learning as a basic principle of transdisciplinarity, In: R.W. Scholz, R. Häberli, A. Bill and M. Welti, (Eds.), Transdisciplinarity. Joint Problem-Solving among Science, Technology and Society, 2000, Haffmans; Zürich, 13–17.

[66] J. Spangenberg, Sustainability science. A review: an analysis and some empirical lessons, Environ. Conserv. 38, 2011, 275–287.

[67] P. Strohschneider, Zur Politik der Transformativen Wissenschaft, In: A. Brodocz, D. Herrmann, R. Schmidt, D. Schulz and J. Schulze-Wessel, (Eds.), Die Verfassung des Politischen, 2014, VS Verlag für Sozialwissenschaft; Wiesbaden, 175–192.

[68] G. Teubner and H. Willke, Kontext und Autonomie: gesellschaftliche Selbststeuerung durch reflexives Recht, Z. Rechtssoziol. 6 (1), 1984, 379–390.

[69] W. Van Den Daele, Objektives Wissen als politische Ressource. Experten und Gegenexperten im Diskurs, In: W. Van Den Daele and F. Neidhardt, (Eds.), Kommunikation und Entscheidung. Politische Funktionen öffentlicher Meinungsbildung und diskursiver Verfahren, 1996, Edition Sigma; Berlin, 297–326.

[70] B. Ward and R. Dubos, Only One Earth. The Care and Maintenance of a Small Planet. An Unofficial Report Commissioned by the Secretary-General of the United Nations Conference on the Human Environment, Prepared with the Assistance of a 152-member Committee of Corresponding Consultants in 58 Countries, 1972, Penguin; Harmondsworth. E. Von Glaserfeld, Radical Constructivism: A Way of Knowing and Learning, 1995, Routledge; London.

[71] Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen (WBGU), Welt im Wandel Gesellschaftsvertrag für eine Große Transformation, 2011, Zusammenfassung für Entscheidungsträger; Berlin.

[72] P. Weingart, Wissenschaftssoziologie, 2003, Transcript; Bielefeld.

[73] M. Welp, A. De La Vega-Leinert, S. Stoll-Klugeemann and C.C. Jaeger, Science-based stakeholder dialogues. Theory and tools, Global Environ. Change 16 (2), 2006, 170–181.

[74] A. Wiek, L. Withycombe and C. Redman, Key competencies in sustainability: a reference framework for academic program development, Sustain. Sci. 6, 2011, 203–218.

[75] H. Willke, Entzauberung des Staates. Überlegungen zu einer sozietalen Steuerungstheorie, 1983, Athenäum Verlag; Königstein/Taunus.

[76] H. Willke, Strategien der Intervention in autonome Systeme, In: D. Baecker, J. Markowitz, R. Stichweh, H. Tyrell and H. Willke, (Eds.), Theorie als Passion. Niklas Luhmann zum 60. Geburtstag, 1987, Suhrkamp; Frankfurt am Main, 333–361.

[77] T. Yosie and T. Herbst, Using Stakeholder Processes in Environmental Decision-making: An Evaluation of Lessons Learned, Key Issues, and Future Challenges, 1998, Ruder Finn Washington; Washington.