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Essay

Key Issues of Interdisciplinary NEXUS Governance Analyses: Lessons Learned from Research on Integrated Water Resources Management

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Abstract: Governance has become a cornerstone in addressing complex linkages between multiple resources such as water, energy, and food. However, contributions of governance research in interdisciplinary research projects are either lacking or highly controversial. Drawing on Integrated Water Resources Management-related experiences of German research projects in emerging and developing countries, we demonstrate how to strengthen NEXUS-related governance analyses: There has to be a stronger focus on the analyses of existing and useful governance strategies as well as of conditions for governance transitions; governance analyses should refer to different types of problems, instead of only focusing on single cases and abstract analyses; and answers must be based on a more elaborate practice of inter- and transdisciplinary research. These suggestions should be implemented on the level of single researchers, but should also require incentives on an institutional level.

Keywords: NEXUS governance; science policy interface; complexity; complex problem solving; IWRM

1. Introduction

Water, food and energy are inherently connected and therefore demand an integrated governance approach. Building on former experiences of the authors [1], this paper presents key issues of interdisciplinary NEXUS governance analyses by discussing lessons learned from IWRM research. The Water–Energy–Food (WEF) NEXUS approach was introduced by the World Economic Forum in 2011 [2]. The approach was introduced by the World Economic Forum in 2011 [2]. Since then, it has gained significance in both practice and academic research [3–6]. The concept criticizes "current and often sector-specific governance of natural resource use" ([3], p. 390) and highlights, instead, interdependencies between the production and use of water, energy, and food [7]. Proponents of the concept suggest that, by governing these resources in an integrated manner, problems such as resource scarcity, quality, and human wellbeing will be addressed in a more sustainable way. The concept has thus also become a cornerstone in achieving and monitoring the Sustainable Development Goals (SDGs) [3].

Just as other upcoming concepts, however, the NEXUS approach is still under development and raises, as such, a couple of open questions. Researchers and practitioners perceive NEXUS problems differently, so that the concept is often used as a buzzword with different meanings [8]. The concept also lacks an analytical framework for integrated scientific analysis. Just as in other fields of research, methods for a substantiated science-policy interface—defined here as a "continuous interaction between science and policy"—are still to be developed [4]. Establishing a substantiated science

policy interface is particularly challenging given the complex interactions of water and soil in the environment, with direct impacts on food and energy provision ([9], p. 2). The existing knowledge about the interaction of different resource types has to be prepared in a way that can be fruitfully used in decision-making processes.

We argue that open issues in the debate on NEXUS governance, such as finding a common methodology for analyses, can benefit from debates on Integrated Water Resources Management (IWRM). IWRM researchers and practitioners have generated lessons learned that can inform analyses and the practical implementation of NEXUS governance. A prominent example is the recognition of the link between introducing IWRM and capacity development to ensure effective IWRM implementation also in the long term [10]. Moreover, guidelines such as A Handbook for Integrated Water Resources Management in Basins [11] and The IRS Handbook [12] can serve as the basis for analyzing the NEXUS and its underlying governance structures.

The link between the two approaches—WEF-NEXUS and IWRM—has been widely acknowledged indeed [13–17]. As shown in Table 1, the similarities between the two are numerous: in both concepts, participatory approaches are encouraged to address integrated management problems. There are various scales for problem solving, e.g., the local, national, regional, and international scale. Interdependencies and trade-offs are very similar, e.g., related to environmental and social goals. The main difference is that IWRM has a strong water, and as such a basin or sub-basin, perspective, whereas this is not necessarily the case with regard to NEXUS concepts and perspectives. Many NEXUS concepts may also be water-centric [18] or even have a basin perspective [19]. However, the WEF-NEXUS generally does not prioritize water but aims at balancing water, energy, and food [20] and wishes to increase resource use efficiency as such [21]. The NEXUS concept also streamlines broader IWRM visions by focusing on specific resources or sectors [22].

Table 1 recaps important similarities that support the perspective that lessons learned from IWRM can be transferred to the analysis of the WEF-NEXUS.

Table 1. IWRM and NEXUS—Similarities and differences.

Criteria	IWRM	WEF-NEXUS
Interdependencies and trade-offs	Between different water using sectors such as agriculture, tourism, and industry	Between different water-, energy-, and food-related sectors such as agriculture, tourism, industry
Scale for problem solving	Local, national, regional, international levels, special emphasis on basin and sub-basin levels	Local, national, regional, international levels (basin level possible but not mandatory)
Stakeholder integration	Multi-level and multi-sector stakeholder integration	Multi-level and multi-sector stakeholder integration

Our analysis is based on practical experiences from international IWRM research projects, funded by the German Ministry of Education and Research (BMBF). This includes experiences related to 15 projects, among them projects of the funding initiatives "Integrated Water Resources Management," "International Water Research Alliance Saxony," "Research for Sustainable Development of Megacities of Tomorrow," and "Global Change and the Hydrological Cycle." (For a detailed overview of the projects, see [23]). These projects were all interdisciplinary in scope, stressed the *governance* of waters to different extents, and were implemented under similar framework conditions (funding schemes and project requirements), but also represented various regional settings (e.g., Asia, Africa, and Europe). They thus provide an interesting starting point for generating lessons learned on governance within interdisciplinary research projects related to various regional framework conditions while keeping the overall funding conditions rather constant.

The main focus of these projects was on managing water in a way that social and economic objectives are met without jeopardizing important ecosystems [24,25]. In theory, governance research has a fixed place in such analyses [24]. However, looking at the BMBF's funding

programme IWRM, it became clear that the potential of governance analyses is not exhausted in the creation of sustainable solutions to resource problems. Numerous discussion processes between governance researchers within a multi-year networking project showed that researchers encounter various problems in the projects that reduce their impact on troubleshooting. At the same time, recommendations emerged as to how these problems could be overcome.

The results of the discussion processes clearly show: The problem is not primarily the often-criticized heterogeneity of the terminology. Although the definition screen of "governance" is colorfully painted, there seems to be a relative consensus on understanding water governance as the totality of institutional and actor-specific conditions that characterize the process of decision-making and implementation in the water sector. Such a definition is also applicable or even in line with existing understandings of governance in other fields of practice such as the WEF-NEXUS, an integrated resource management approach, or non-resource management related policy fields (e.g., [26]). In the NEXUS debate, for instance, governance questions often revolve around the actors and institutions that are in place in order to decide on and implement successful policies related to an integrated management of resources and sectors (e.g., [6]).

However, we argue that further scientific analyses of governance conditions are rather problematic. These should be strengthened in interdisciplinary research projects, so that they can contribute to the goal of sustainable resources management. Interdisciplinarity in research projects refers here to linking bounded disciplines, e.g., to solve environment-related problems. Environmental science is an interdisciplinary field [27] that requires the interlinkage between social and natural sciences to solve today's urgent problems [28]. Because of the similarities between IWRM and the NEXUS approach that are outlined in Table 1, we chose to transfer strengthening potentials we identified for IWRM [1] to the NEXUS discussion. Strengthening potentials consider three aspects in particular: (1) the questions to be addressed in interdisciplinary NEXUS governance research; (2) the kind of answers governance researchers can give to these questions; and (3) the collaborations that we can enter into to find these answers.

2. Which Questions? Analyses beyond Simple Descriptions and a Science-Policy Interface

Experiences from IWRM funding measures clearly show that governance analyses are often reduced to two aspects: portfolio analyses and selected contributions to the study of a science-policy interface. For portfolio analyses, the identification of formal rules, such as water laws and regulations, as well as responsible actors in the political and administrative system are core. Often, these analyses are carried out by the participating natural scientists themselves, to find suitable collaboration partners; social science expertise is scheduled for this to a very limited extent. Contributions to the science-policy interface mainly relate to a mutual knowledge transfer between science and practice.

The focus in these projects is often related to the transfer of scientific results into practice. Participating social scientists are then, if necessary, reduced to the role of "agents" of natural scientists. With this focus on portfolio analyses and selected contributions to the study of a science-policy interface, both deeper analysis on the governance conditions for the implementation of IWRM and research-related governance contributions to the science-policy interface are omitted. Unless exceptions existed [10], they did not precede the scientific and technical research process, but ran in parallel due to short funding periods. Consequently, specific technical solutions are not integrated into the institutional framework.

These reductions in inventory analyses and contributions to the science-policy interface are problematic. They suggest that, based on the knowledge of key actors and institutions, the necessary conditions for an improvement on-site are given. However, we forget that resource-related political and social decision-making and change processes are more complex: actor constellations and institutional frameworks can be very heterogeneous and vary depending on the context and phase of the political process. Change processes of governance structures are more than challenging—confirming itself already in development practice every day. A lack of understanding of the structures and processes in the absence of social science expertise can influence the success of

a project. This is, for example, the case when technical solutions are offered without adequate governance-related problem analysis that decisively influences the sustainable implementation of technical solutions. Research projects then run the risk of not being effective in terms of the implementation of concepts.

For NEXUS projects, it is therefore necessary to better integrate governance-related research. Specifically, questions about the determinants of existing structures as well as for appropriate governance structures and the conditions, possibilities, and limitations of change must be made central to governance analysis. In particular, actor analyses are still very hesitantly integrated into governance research. Likewise, it remains unclear how complex cooperative relationships can be designed both more efficiently and effectively in theory and practice. Theoretical and methodological instructions for this kind of analysis already exist [29]. Based on a solid social science analysis of governance structures and processes—also with the help of these tools—governance analysis can make specific recommendations in terms of guidance for the design or the transformation of NEXUS governance systems. On the basis of such recommendations, capacity development measures can contribute to specifically improve governance conditions on-site. This path can only be taken if research funding emphasizes not only the relevance of social factors, but also demands their specific analysis.

3. Which Answers? Explanations and Solutions between Specificity and Abstraction

Governance analyses result in different types of answers: On the one hand, researchers generate single case studies, which result in governance analyses and solutions that are highly sensitive to context. Such kinds of analyses are very common in the IWRM research initiative on IWRM [30–33]. On the other hand, the literature provides highly abstract analyses and solutions, which can be applied to various types of contexts. These solutions relate to single governance strategies such as participation [34] or river basin organizations [35]. Rarely, however, researchers' contributions aim at comparative analyses and solutions for specific *types of problems* such as various forms of conflicts between resource users. Single contributions in this regard show that such analyses come along with numerous challenges [33].

This focus on single case studies and abstract approaches has, without any doubt, important advantages. However, it also has significant shortcomings. Single case studies, on the one hand, have the advantage of considering numerous influencing factors on the design of governance systems. They thus lay the groundwork for the explanation of the respective case and, where applicable, the development of precisely fitting governance strategies. However, respective results can hardly be transferred to other contexts. Abstract approaches, on the other hand, emphasize the general relevance of specific explanatory factors. They thus provide important connection points for single case studies. They are, however, very abstract, with the result that their application to practical case studies requires manifold exemptions and adjustments.

To address these problems, the advantages of both approaches can be combined in NEXUS governance analyses. Next to single case studies and abstract analyses, researchers can aim for comparative analyses of specific *types of NEXUS problems*. There are several criteria to define types of problems, among them structural, thematic, and regional criteria. In terms of structures, researchers can analyze governance strategies to address problems of similar or different degrees of complexity [36]. In terms of thematic contents, researchers can compare similar NEXUS issues in various contexts, e.g., the development of coherent policies on a national level, or solutions to specific problems, such as leaching in agriculture and regulatory mechanisms to address land and water pollution from abandoned sites. In terms of regions, researchers can focus on similar or varying natural, socio-economic, political, and cultural contexts. These types of comparative analyses are particularly well suited for big research initiatives encompassing a large number of problems. In reference to the German research initiative on IWRM, however, we observe that funders are rather reluctant to claim such comparative approaches in relevant calls.

4. Which Cooperations? Inter- and Transdisciplinary Collaboration in Governance Research

Inter- and transdisciplinary cooperation has become increasingly relevant and not only in the IWRM funding initiative [24]. Whereas interdisciplinarity is research-centered, transdisciplinarity relates scientific and societal problems and "produces new knowledge by integrating different scientific and extra-scientific insights; its aim is to contribute to both societal and scientific progress" ([37], p. 8). NEXUS research is especially demanding of inter- and transdisciplinary approaches because technical feasibility and human behavior are cornerstones of reducing the trade-off between water, energy, and food provision.

The implementation of inter- and transdisciplinary research approaches is challenging and typically encompasses a set of barriers. First, governance analyses rarely involve all the relevant social scientific disciplines such as political science, economics, and law. This may go back to the predominant role of the natural and engineering sciences in leading such projects. Second, governance analysts on the one hand and technical and natural scientific disciplines on the other seem to not fully exploit each others' benefits for their own work. This does not just refer to a mutual understanding of questions and answers, but to the use of the results of other disciplines for their own purposes.

Third, there are several challenges when it comes to the collaboration with partners from practice such as economic and developmental actors. Practitioners' and scientists' actions seem to overlap increasingly, meaning that practitioners undertake scientific tasks, whereas scientists are charged with the implementation of research results (e.g., in the field of participation [38]). Further, the exchange between researchers and practitioners is limited, be it on a project or an institutional level. Moreover, governance analyses often take place at the same time as adapted research projects aimed at implementing research results. Results of governance analyses thus often coincide with the ends of projects, even though they should, in some cases, take place prior to implementation activities. Consequently, governance conditions can often not be considered adequately when choosing technologies to address resource problems. Such simultaneous analyses also reduce possibilities to systematically build upon the results of governance analyses in upcoming capacity developments activities.

These deficits are particularly problematic since they significantly reduce the potential for learning effects. There are various states of knowledge even within one discipline, which can only be unveiled by intensive discourse. The exchange between various disciplines that conduce governance analyses thus enables the consideration of the various facets of a problem. The exchange with natural scientists can further increase the relevance of governance analyses, e.g., by providing information on specific natural scientific problems that should also be addressed by governance researchers. The intensive exchange between scientists and practitioners fosters the exchange of knowledge, resulting in both improved scientific analyses and the possibilities to implement scientific results. Besides, such an exchange prevents inefficiencies of pursuing similar questions and types of tasks in different sectors, which is, for instance, the case if both scientists and practitioners have to learn implementation-oriented know-how.

To address these problems, inter- and transdisciplinary collaboration should be strengthened in NEXUS governance research. This relates to single researchers as well as to the relevant implementation agencies, and scientific and donor organizations. Such intensified collaboration should aim at well-matched analyses of problems in particular. This is particularly time-consuming and challenging in international scientific contexts, given various cultural traditions and behaviors [39,40]. Collaborative processes should further clearly define the respective roles of all participating actors. Here, it is important to remember the core area of various disciplines and sectors. Scientists, on the one hand, should contribute to preparing practitioners' work—a task which does not exclude, but explicitly requires learning from practitioners' experiences. Practitioners, on the other hand, can take up scientific results and facilitate their implementation. Such a form of collaboration is only successful if governance analyses take place, at least in part, prior to implementation oriented research projects [29,39]. Finally, institutionalized dialogues have to be intensified and to be characterized by an inter- and transdisciplinary openness and basic education. Such prerequisites

are necessary to finding a common language and to create mutual understanding and interests for a more effective exchange of knowledge.

5. The Three Facets of Strengthening NEXUS Governance Research

In summary, our experiences suggest that governance analyses are to be strengthened fundamentally in order to address problems within interdisciplinary NEXUS governance research. Such strengthening first encompasses a stronger focus on analyses of existing and useful governance strategies as well as of conditions for governance transitions. Limitations to the identification of relevant institutions, e.g., by natural scientists alone, are not sufficient to understand conditions for the existence and change of governance structures. Second, governance analyses should refer to different types of problems, instead of only focusing on single cases and abstract analyses. This facilitates the transfer of results to various contexts. Third, we can only find answers if the call for inter- and transdisciplinary research is taken seriously, which goes, evidently, beyond the sheer knowledge of any individual researcher. These three suggestions to strengthen interdisciplinary NEXUS governance research should not just be implemented on the level of single researchers. They rather require incentives on an institutional level and on behalf of relevant donors.

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