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Governance of the Water- Energy-Food Nexus for an Integrated Implementation of the 2030 Agenda

Conceptual and Methodological Framework for Analysis

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Abstract

Implementing the 2030 Agenda requires an improved understanding of the interdependencies among the Sustainable Development Goals (SDGs) and targets and the design and implementation of coherent policies across different levels and sectors. The water-energy-food (WEF) nexus has emerged over the past decade as a useful concept to reduce trade-offs and increase synergies in promoting goals of water, energy and food security. While WEF scholarship substantiates the biophysical interlinkages and calls for increased and effective coordination across sectors and levels, knowledge about the conditions for effective coordination is lacking. We aim to contribute to this understanding by conceptualising WEF nexus governance from an analytical perspective as a polycentric system and by developing a framework based on the concept of networks of adjacent action situations (NAASs).

The interdependence among transactions for pursuing WEF securities by actors in the differing action situations generates a need for coordination in changing or sustaining institutions, policy goals and policy instruments that guide actions leading to sustainable outcomes. Coordination is achieved through arrangements based on cooperation, coercion and competition. Coordination in complex social-ecological systems is unlikely to be achieved by a single governance mode but rather by synergistic combinations of such modes. Particular coordination arrangements that emerge in a given context depend on the distribution of authority, information and resources within and across interlinked decision-making centres. Integrating the political ecology-based conceptualisations of power into the analytical framework further extends the governance analysis to include the influence of power relations on coordination. Methodological innovation in delineating action situations and identifying the unit of analysis as well as integrating different sources and types of data are required to operationalise the conceptual framework.

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Contents

Abstract

Acknowledgements

Abbreviations

1	Introduction – WEF nexus in the context of Agenda 2030	1
2	Review of the WEF nexus governance	3
2.1	Approaches used in WEF nexus research and practice	4
2.2	Approaches to analysing WEF nexus governance	6
3	Building a framework for analysing WEF nexus governance	8
3.1	WEF nexus governance from a polycentricity approach	9
3.2	A conceptual framework for WEF nexus governance	12
3.2.1	Natural resources as “common pool” resources	12
3.2.2	Institutions	12
3.2.3	Actors, action situations and network of adjacent action situations (NAAS)	13
3.2.4	Transaction interdependence and the need for coordination	14
3.2.5	Coordination among decision centres/action situations	15
3.2.6	Governance modes and policy instruments	17
3.3	Illustrating networked adjacent action situations for WEF nexus analysis	18
3.3.1	“Power” in the analysis of polycentric WEF nexus governance	20
4	Methods for analysing WEF nexus governance	21
5	Conclusions	22
	References	25

Figures

Figure 1:	WEF nexus governance – a conceptual framework	11
Figure 2:	WEF governance as network of adjacent action situations	19

Abbreviations

CPR	common pool resource
EU	European Union
FMIS	farmer-managed irrigation system
IAD	institutional analysis and development
ICSU-ISSC	International Council for Science-International Social Science Council
INRM	integrated natural resources management
IWRM	integrated water resources management
LNOB	leave no one behind
NAAS	network of adjacent action situations
SDG	Sustainable Development Goal
SES	social-ecological system
SNA	social network analysis
WEF	water-energy-food
WUA	water user association

1 Introduction – WEF nexus in the context of Agenda 2030

The seventeen Sustainable Development Goals (SDGs) that constitute the 2030 Agenda encompass multiple sectors and multiple levels of policymaking. The interdependencies among different goals and the importance of coherent policies/strategies to achieve the SDGs have also been widely acknowledged (Le Blanc, 2015; Pahl-Wostl, 2019). Furthermore, the institutional and political preconditions for achieving sustainability goals are also an integral part of the Agenda (SDGs 16 and 17). A safely operating biosphere, which includes various land and water resource and climate systems, is also crucial if the social and economic goals are to be achieved (Rockström & Sukhdev, 2016). What distinguishes the SDGs from earlier approaches towards achieving social, ecological and economic objectives is the realisation that the traditionally fragmented policies in pursuing different dimensions of sustainability have not yielded the intended results (Le Blanc, 2015).

However, the currently persisting water, energy and food insecurities for billions of people and the projected increase in the demand for water, food and energy by 2030 (40-50 per cent) will exert even more pressure on scarce natural resources, especially land, water and biodiversity. Unless the trade-offs among policy goals pertaining to different sectors are addressed and policy coherence achieved, pressure on fragile resource systems will increase and may transgress the planetary boundaries. Among several approaches intended to improve policy coherence, the water-energy-food nexus concept has gained much popularity and prominence since its inception in 2011 (Simpson & Jewitt, 2019; WEF [World Economic Forum], 2011). The WEF nexus originated as a normative concept – “to promote policy coherence through identifying optimal policy mixes and governance arrangements across the water, energy and food sectors” (Weitz, Strambo, Kemp-Benedict, & Nilsson, 2017, p. 165). The concept aims at promoting a systems’ perspective in achieving multiple policy goals (Bazilian et al., 2011; Hoff, 2011).

Although the WEF nexus concept preceded the adoption of Sustainable Development Goals, there is increasing recognition of its importance in guiding the understanding and managing of interdependencies among different goals and targets (Müller, Janetschek, & Weigelt, 2015; Pahl-Wostl, 2019). The SDGs most directly related to the WEF securities are goals 2, 6 and 7 (Altamarino et al., 2018; Mohtar, 2016). According to an earlier review conducted by the International Council for Science-International Social Science Council (ICSU-ISSC, 2015), these SDGs have been found to have strong interlinkages with most of the other SDGs and targets except SDGs 16 and 17. However, when we broaden the perspective of the WEF nexus concept beyond the securities, strong institutions (SDG 16) and multi-stakeholder partnerships (SDG 17) are crucial to managing the interlinkages and ensuring integrated implementation of the 2030 Agenda.

There have been many interpretations and applications of the WEF nexus-concept based on the disciplinary and sector inclinations of the researchers (Simpson & Jewitt, 2019). However, the majority of scholars have focused on resource security and addressed the interdependencies between the resource-based sectors of food, energy and water (Pahl-Wostl, 2019). While water was initially the only resource considered at the centre of WEF securities, some researchers have since argued for the inclusion of soil/land and biodiversity as crucial inputs for the nexus securities and climate targets (< 2°C world) as boundary conditions (Hatfield, Sauer, & Cruse, 2017; Müller et al., 2015).

Despite the “buzz” created by the WEF nexus-concept, there has not been much progress in the development and implementation of coherent policies and instruments towards furthering the nexus securities (Albrecht, Crotofof, & Scott, 2018; Galaitsi, Veysey, & Huber-Lee, 2018). It is true that the new approach sparked off research, generating considerable evidence mainly on the biophysical interdependencies (trade-offs and synergies) among different sub-systems (Yung, Louder, Gallagher, Jones, & Wyborn, 2019), resource efficient technologies in particular sectors (Chang, Li, Yao, Zhang, & Yu, 2016), and specific policy instruments along with their impact on one or all of the WEF securities (Never & Stepping, 2018; Rasul, 2016; Rodríguez-de-Francisco, Duarte-Abadía, & Boelens, 2019). Also, most studies used biophysical, economic or mixed systems modelling approaches (Albrecht et al., 2018; Liu et al., 2017; Yung et al., 2019). However, in addition to knowledge about the physical linkages of the sub-systems, a sound understanding of the institutional interlinkages among them is likewise required if coherent strategies are to be fostered (Scheumann & Phiri, 2018; Villamayor-Tomas, Grundmann, Epstein, Evans, & Kimmich, 2015; White, Jones, Maciejewski, Aggarwal, & Mascaro, 2017).

WEF securities are provided by complex interactions within social-ecological systems (SEs). Ensuring WEF securities requires sustainable resource governance involving different actor-types (state, private sector, civil society), sectors (mainly water, food and energy) and scales (political/administrative, ecological and even temporal). Conventionally, in all countries the provision of these public or collective goods (water, energy and food) is organised in administratively separated public units/sectors (Scheumann & Phiri, 2018). Very much aligned to that, analyses of institutions and governance of SEs have so far focused mainly on single collective goods. Few systematic studies currently exist with the aim of understanding how these interdependencies are governed in order to provide multiple collective goods and services of varying priorities to different sections of society. In addition, there is no consensus in the literature on how this could and should be done. While there have been attempts to integrate biophysical and socio-economic approaches to assess the interactions at the systems level, institutions and governance as drivers or outcomes of these system-level interactions have received little focus (for a small number of exceptions focusing on institutions as causes, see Kimmich (2013); Villamayor-Tomas et al. (2015); for institutions as outcomes, see Märker, Venghaus and Hake (2018)).

The objective of this paper is hence to extend the rich conceptual discussions in the literature on natural resource and environmental governance in order to analyse the interlinkages among strategies in the pursuance of WEF securities. It further aims at arriving at a framework for analysing the effectiveness of institutions and governance mechanisms in achieving water, energy and food securities while ensuring the sustainability of the natural resource base as well as the “leaving no one behind” (LNOB) principle of Agenda 2030.

We propose conceptualising WEF nexus governance as a polycentric system. This will be helpful in breaking down the complex process of provision of differing public goods (water, energy and food) organised through various decision centres/action situations within differing sectors at various levels with social, economic and biophysical interlinkages. Polycentric governance has emerged both as a normative and analytical concept for natural resource governance (Thiel, 2016; Thiel, Garrick, & Blomquist, 2019). While it has been claimed that polycentric governance is a desirable system for resource governance and climate change mitigation (Anderies, Janssen, & Ostrom, 2004; E. Ostrom, 2012), there have also been increasing efforts to apply polycentricity as an analytical concept in

examining the governance of complex resource systems such as water (Blomquist, 2009; Marshall, 2009; Thiel, 2015). The concept of polycentric governance allows for multiple autonomous but interdependent decision-making centres involving overlapping actors and scales operating in the context of an overarching institutional context, which facilitates/constrains the interactions among the centres (McGinnis, 2011). The formally independent constituent centres of a polycentric system may interact in three possible ways: through cooperation; conflict or conflict resolution; and competition (V. Ostrom, Tiebout, & Warren, 1961). Further, the key elements of authority, information and resources affect the incentives of multiple centres to interact in a particular way (Koontz & Garrick, 2019).

In order to identify and analyse the key decision-making centres, their interactions and outcomes as well their underlying factors, we propose to apply the network of adjacent action situations (NAAS) approach proposed by McGinnis (2011) as an analytical tool. We believe that viewing the provision-related activities of water, energy and food as formally independent action situations, and studying their interactions will help us to understand the performance of existing governance in harmonising these interactions, and ensuring the achievement of WEF-related SDGs.

In the remainder of the paper, we begin by reviewing existing literature on nexus governance, identifying gaps in the literature in Section 2. After that, in Section 3, we conceptualise WEF nexus governance as a polycentric system and propose the NAAS as a tool with which to understand the interactions among differing focal action situations and their outcomes. We discuss the available choice of methods in Section 4, before providing conclusions in Section 5.

2 Review of the WEF nexus governance

The WEF nexus is promoted as a governance solution to complex resource management challenges (Hoff, 2011). The WEF nexus concept serves multiple purposes – as an analytical tool, a conceptual framework, or a discourse (Keskinen et al., 2016, p. 3). As an analytical tool, WEF nexus analyses typically include either quantitative or qualitative approaches or both in understanding the interactions and interdependencies among water, energy and food systems (Albrecht et al., 2018). However, as a normative governance concept to achieve policy coherence, the WEF nexus has had limited success – if any – so far. As a discourse, though, it has made a significant contribution in terms of framing or reframing the problem of resource governance, especially of water. The WEF nexus framed as a governance challenge (Pahl-Wostl, 2019) presents a unique framing of the challenge of resource governance where different societal goals implicit in the policies to secure water, energy and food security compete with each other for resources.

The concept of integration in resource governance and provision of food, water and energy services was prevalent in research and policy spaces prior to the arrival of the WEF nexus concept. The concepts of integrated natural resources management (INRM), integrated water resources management (IWRM), and multi-functional agriculture (Maier & Shobayashi, 2001) emphasise integration of policies and processes towards recognising and internalising both positive and negative externalities generated as a result of economic activities of food, water or energy provision (Pahl-Wostl, 2019). With the exception of the success of INRM,

which focuses predominantly on local natural resources, there has been limited success in the fields of IWRM or multi-functional agriculture (Pahl-Wostl, 2019; Wichelns, 2017).

Implementation problems of IWRM have been widely reported although a majority of countries have adopted its principles in their laws and policies (see, for example, Horlemann & Dombrowsky, 2012 for Mongolia; Kim & Hornidge, 2016 for Uzbekistan). Overcoming the huge lack of institutional capacity for cross-sectoral governance has not been possible so far and this has affected the effective implementation of IWRM (Pahl-Wostl, 2019). Kurian (2017) concurs that the focus of IWRM on hydrological boundaries, while neglecting the administrative or jurisdictional boundaries and the scales of other securities has limited the success of IWRM. Some researchers argue that – by advocating the shift of the focus from sectoral “silos” to more integrated policymaking – the WEF nexus could assist in solving the problems of IWRM (Simpson & Jewitt, 2019). To a certain extent, the WEF nexus has been successful in spreading the concept of integrated governance beyond the water sector into the debates on food, energy and across state, private sector and civil society actors (Benson, Gain, & Rouillard, 2015). However, in order for WEF nexus thinking to successfully guide policies towards ensuring WEF securities through the sustainable management of resources, the challenges encountered by the earlier integrated approaches need to be addressed along with additional challenges posed explicitly by the nexus itself.

In the remainder of this section, we first conduct a short recap of the analytical approaches used in studying the WEF nexus by various disciplines along with their key contributions to understanding the interlinkages. In addition, we present a quick scan of the literature pertaining to WEF nexus governance. We would like to mention that this is neither an exhaustive nor a systematic review of the broader nexus literature and the nexus governance literature. We draw upon several recent systematic and selected reviews of the topic published in peer-reviewed journals (for instance, Weitz et al. (2017) for a WEF governance review; Albrecht et al. (2018) for a comprehensive review of approaches to studying the WEF nexus; Chang et al. (2016) for quantitative approaches; Yung et al. (2019) for how methods include uncertainty). We have also reviewed a selection of grey literature (such as FAO [Food and Agriculture Organization of the United Nations], 2014; Galaitsi et al., 2018) published by international agencies promoting or analysing WEF nexus approaches. Along with this, articles focusing on the governance of the WEF nexus using case studies have been reviewed for their approaches as well as publications critical of the WEF nexus (Allouche, Middleton, & Gyawali, 2014; Galaitsi et al., 2018; Wichelns, 2017). These systematic reviews and other reviews are presented to support the conceptual framework described in the subsequent section (Section 3).

2.1 Approaches used in WEF nexus research and practice

While the earlier attempts to study the WEF nexus focused on the securities of WEF and WEF as an opportunity for the emergence of the Green Economy (Pahl-Wostl, 2019; WEF, 2011), the scholarly focus has since shifted to the interdependencies within the nexus and the need for sustainable governance of natural resources (Pahl-Wostl, 2019). In contrast to the broad conceptualisation of WEF nexus, Albrecht et al. (2018, p. 4) contend that methods and tools to quantify and assess WEF interlinkages have not been sufficiently developed and have mostly been “borrowed or adapted from the conventional disciplinary approaches”. With their limited ability to capture the interconnections and interdependencies among the sub-

systems, these tools and methods mostly provide a narrow and fractured perspective of the nexus, which is not in line with the goals of the nexus (Albrecht et al., 2018).

Albrecht et al. (2018) provide a comprehensive review of WEF nexus methodological studies (n=73) from different disciplines with a focus on approaches (methods and tools). They found that, so far, the majority of the approaches used to study the WEF nexus applied methods gleaned from environment management and economic disciplines or a combination of both (60 per cent), with the predominance of quantitative assessments (70 per cent). Among the tools used most frequently were life-cycle assessments, input-output analyses, trade-off analyses, footprinting, or integrated models with scenario analyses. Some studies used a combination of these tools. The social science methods used (26 per cent) mostly included institutional analysis, the Delphi technique, agent-based modelling and participatory workshops. More than half of the instances of research published showed a preference in problem framing or in choice of methods for one of the WEF sectors, with water dominating all sectors. Only 19 per cent of the studies prioritised two or three sectors (Albrecht et al., 2018).

The quantitative estimations of WEF interconnections, as summarised by Chang et al. (2016) also faced methodological hurdles as calculation results were scattered across a wide collection of studies in multiple disciplines. Such approaches generally attempt to quantify impacts of water, energy and food producing technologies and practices on all three sectors. Chang et al. (2016, p. 2) discovered that these quantifications were “still immature” suffering from “inconsistent impact indicator selections, different system boundary definitions, segmented uses of bottom-up and top-down approaches”.¹

The use of disciplinary tools and methods to understand the interdependencies was found to limit the current approaches. Moreover, heavy reliance on quantitative approaches alone was found to be not sufficient (Albrecht et al., 2018): without the inclusion of contextual factors, the design of socially and politically feasible resource use (management) policies is problematic (Endo et al., 2015; Foran, 2015). In their study of nexus projects which link science and policy, Yung et al. (2019) found that combining modelling efforts with the approaches of qualitative futures thinking were helpful in including more contextual variables, especially relating to uncertainty. Although these methods can be challenging for both researchers as well as stakeholders, the researchers acknowledged that this process led to a “more holistic framing of [the] problem and an acceptance of different types of uncertainties, beyond simple data gaps that are usually included in modelling” (Yung et al., pp. 13-14).

Although the nexus approach explicitly states the need to understand the interlinkages among key nexus sectors for advancing WEF securities and resource sustainability through coherent policies, the existing body of research is generally inconclusive as to the exact magnitude of impacts that pursuing one security has on the others. It is also widely acknowledged that the development of methodologies for even the nearly accurate understanding of the physical interlinkages among the various different sector-specific activities across different contexts is still at a nascent stage. The neo-Malthusian premise and statistics about growing populations, growing energy and food demand, and growing water scarcity have resulted in a reductionist scientific approach to framing the problem as

¹ Here top-down and bottom-up approaches refer to the modelling approaches and should not be confused with the top-down and bottom-up approaches of governance.

that of resource efficiency and resource optimisation in respective sectors (de Grenade et al., 2016; Wiegleb & Bruns, 2018; Yung et al., 2019). The underlying assumption of the approaches in most of the technical studies is that improved knowledge of the physical interlinkages and technical and managerial solutions would be sufficient to achieve the respective goals related to WEF securities. However, research on technology adoption in resource-based sectors has provided ample evidence that such adoption is mediated and constrained by institutions and governance mechanisms.

From the various reviews, it is clear that the dominant scientific discourse which takes a technical-managerial view of the WEF nexus problem and its solutions ignores the power relations and social inequalities as causes and consequences of actions (de Grenade et al., 2016; Wiegleb & Bruns, 2018). There is an increased recognition of the need to include the issues of governance and the political economy of the concerned policy fields (Allouche et al., 2014). Pahl-Wostl (2019, p. 357) argues that WEF nexus is so far rooted in the scientific and technical rationalities for integration, accounting little for the “power constellations, political economy issues, and transaction costs and how they vary at and across different spatial scales”. Considering the wide array of dimensions of the WEF nexus as evident from the diverse approaches from different disciplines, a comprehensive understanding of the WEF nexus in a given context requires a combination of different methods from different disciplines employing both quantitative and qualitative techniques as well as active engagement with stakeholders and decision makers (Albrecht et al., 2018).

2.2 Approaches to analysing WEF nexus governance

As evident from the comprehensive review undertaken by Albrecht et al. (2018), systematic analyses of the governance of the WEF nexus in particular have been limited. In much of the nexus debate, an explicit focus on governance is missing (Al-Saidi & Elagib, 2017). In their review of governance approaches to the WEF nexus, Weitz et al. (2017) categorised the literature as characterised by three perspectives, namely, technical (based on risk and security arguments); administrative (based on economic rationality); and political (based on the concerns of equity and power). The common proposition of all the perspectives, however, is that – in a given context – cross-sectoral coordination is required for managing the interlinkages and attaining WEF securities. However, Weitz et al. (2017) also argued that the technical and administrative perspectives do not explain why coordination does not occur, nor what the main barriers to coordination are.

If the interdependencies in the WEF nexus are to be addressed, both horizontal (across sectors) and vertical (across scales and levels) coordination are essential (Pahl-Wostl, 2019; Weitz et al., 2017). The primary objective of the WEF nexus governance analysis should be to unravel the conditions under which there is successful coordination among multiple interlinked decision/action situations. However, prior to the focus on coordination, it is important to identify and distinguish the relevant decision-making/action situations that are interlinked within the issues of water, energy and food. The various studies have employed different approaches to distinguish the interlinked decision situations related to the provision of food, energy and water security. Pahl-Wostl (2019) applied a combination of ecosystem services and actor network concepts and developed a typology of interactions among actors which depended on the type of ecosystem service of interest to the actors involved. The nature of interactions (the degree of directness or indirectness of interactions

among involved actors) determined the type of governance mechanisms that might be effective in enhancing coordination. Further, Pahl-Wostl emphasised the importance of teleconnections among spatially remote actors without any established social relations through which they might influence each other and their interactions with nature, but who were connected through global trade. To this extent, a multi-level perspective was essential in order to address the governance gap in facilitating coordination among decision-making centres across levels and scales. Dombrowsky and Hensengerth (2018) found that regional organisations dealing with energy and river basins were instrumental in facilitating nexus governance in transboundary river projects through negotiating benefit-sharing arrangements and ensuring compliance with social and environmental safeguards.

Villamayor-Tomas et al. (2015) employ a novel combination of the value chain approach and the institutional analysis and development (IAD) framework (E. Ostrom, 2005) as well as the notion of the network of adjacent action situations (NAAS) (McGinnis, 2011) as an extension of the IAD to explore the biophysical and institutional interlinkages across different stages of production and consumption of food, energy and water resources. They select irrigation systems in four countries – Kenya, India, Spain and Germany – as cases of the WEF nexus that represent a close continuum of action situations along the value chain: water appropriation; electricity appropriation; and crop production. They found that the coordination problems identified in various different action situations of water and energy appropriations as well as the related crop-production choices were physically and institutionally interlinked. For example, in the Indian case, the technical and institutional solutions available for the coordination dilemmas relating to the quality of the electricity provided were found to be undermined by a series of institutional factors (subsidies on electricity, ineffective regulation of groundwater withdrawal and promotion of water-intensive crops) which were deeply rooted in the political economy of the country and the federal state (Kimmich, 2013). Further, the informal collusion of farmers and electricity service providers prevented investments to improve infrastructure for electricity generation and its maintenance. Such cross-sector path-dependencies were also found to hinder institutional reform of water and energy sectors in the Spanish case (Villamayor-Tomas et al., 2015).

A lack of recognition of the social embeddedness of interactions among actors was one of the key limitations of earlier approaches to governing water resources such as IWRM. For this reason, Stein, Pahl-Wostl, and Barron (2018) followed a relational approach and analysed how existing social relationships shaped governance processes for WEF nexus interlinkages in the Upper Blue Nile basin in Ethiopia. They identified the network structure for nexus governance in Ethiopia as hierarchic, reinforcing the boundaries around spheres of political authority. Furthermore, they found that rather than sectoral boundaries, hierarchical relationships between actors at different governing levels, geographical locations and jurisdictions structured the interactions among WEF nexus actors (Stein et al., 2018).

WEF nexus literature likewise falls short on the knowledge of political and cognitive factors that determine policy change within the sectors (Weitz et al., 2017). The neglect of the inherently political nature of the WEF nexus problem by the dominant technical-administrative perspective of the nexus literature could possibly explain the dearth of knowledge on why incoherent policies and strategies persist. Failing to include the vertical interactions will provide only a limited understanding of the unintended consequences of the horizontally fragmented policies. The process of formulating and implementing sectoral

policies relies explicitly on vertical coordination, and an analysis focusing on the vertical interplay of institutions can identify many of the factors that shape policy objectives the way they are, together with their effectiveness. Unravelling the institutional political factors behind incoherent sectoral policies and resulting trade-offs among WEF nexus goals require innovative research approaches.

Drawing on the scholarship on integrative environmental governance approaches, Weitz et al. (2017) suggested that coordination across WEF sectors and levels might be fostered through communicative, organisational, and procedural instruments. They further suggest that several attributes (principles) of governance – namely inclusiveness, transparency, accountability, empowerment of the weaker players, and access to information – also have a positive impact on coordination. The transformation of governance systems depends on the cognitive frames of the actors involved and “institutional learning processes” are crucial for such transformations (Weitz et al., 2017, p. 171).

This brief review suggests that most scholarship on the WEF nexus has focused on the biophysical interlinkages (material flows) between the differing sub-systems, generating ample data and evidence proving the strong interdependencies and mutual impact of different sectoral policies. Social, political and institutional interlinkages in the nexus have received comparatively little attention. Nevertheless, in recent years, more and more researchers are applying analytical approaches stemming mainly from environmental governance. Several recent case studies (for example, Never & Stepping, 2018; Rodríguez-de-Francisco et al., 2019) focusing on WEF nexus issues in various geographical contexts have highlighted the embedded nature of the focal WEF nexus decision-making situation (of the particular research) in the horizontal (sectors) and vertical (levels) network of action situations with strong biophysical and institutional interlinkages. These case studies show that there would be value in an analytical approach that is more strongly theorised. There is a need to further enhance the existing conceptual and theoretical framework of WEF governance analysis by systematically analysing more cases in differing environmental, social, economic and political contexts as well as in the context of crucial global goals and conventions such as the 2030 Agenda. Furthermore, the role of important factors in achieving coordination – such as different forms of power influencing the interaction among decision-making centres – need to be better accounted for.

3 Building a framework for analysing WEF nexus governance

It is clear from the review of literature on the WEF nexus that horizontal and vertical coordination is crucial to addressing the complex interdependencies in the nexus. This section introduces polycentric governance as an approach, before taking a positive analytical approach by conceptualising WEF governance as a polycentric system and developing a framework for analysing polycentric WEF governance systems. From a normative standpoint, several researchers have claimed that polycentric governance systems can best solve the complex problems of natural resource or environmental governance problems such as the WEF nexus (E. Ostrom, 2012; Pahl-Wostl, 2019; van Zeben, 2019). They suggest that polycentric governance systems have the “capacity to ... balance bottom-up and top-down (multi-level) and lateral (inter-sectoral) pathways of influence” (Pahl-Wostl, 2019, p. 361). However, only a few studies exist that analyse polycentricity in WEF nexus

governance from a positivist perspective (Kimmich, 2013; Villamayor-Tomas et al., 2015). In this section, we aim to build on the initial attempts and extend the analysis of polycentric governance systems to the case of the WEF nexus. An analytical heuristic to guide the analysis of WEF nexus governance across multiple socio-political contexts is presented.

3.1 WEF nexus governance from a polycentricity approach

Although the concept of polycentricity originated in the 1960s and rich scholarship exists focusing on how provision of the public goods is organised, there exist multiple perspectives with which the term is used in policy and academic fields. Therefore, before we proceed with the detailing of the framework, it is necessary to discuss different perspectives on a few concepts surrounding polycentricity, which are either the underlying approach of the framework or the components. Polycentric governance started as a descriptive concept of Vincent Ostrom and his colleagues with an ontological function of describing the ways in which metropolitan areas organised themselves to provide public goods and services (V. Ostrom et al., 1961). What began as a descriptive label for an observed pattern of societal organisation turned into a theory of polycentricity or polycentric governance. There are normative and positive dimensions to it. In his treatment of the evolution of research on polycentricity (2016), Thiel describes the concept, theory (normative and positive) and analytical framework as different constituents of the polycentricity approach. The concept has ontological, operationalising and sensitising functions. As defined/described by V. Ostrom et al. (1961), polycentric refers to

... many centres of decision-making, which are formally independent of each other. Whether they actually function independently, or instead constitute an interdependent system of relations, is an empirical question in particular cases. To the extent that they take each other into account in competitive relationships, enter into various contractual and cooperative undertakings or have recourse to central mechanisms to resolve conflicts, the various political jurisdictions in a metropolitan area may function in a coherent manner with consistent and predictable patterns of interacting behaviour. To the extent that this is so, they may be said to function as a system. (V. Ostrom et al., 1961, p. 831)

Normative polycentric governance theory makes “hypothetical, value-laden statements about ways in which societies organise themselves in order to comply with certain performance criteria that are considered desirable” (Thiel, 2016, p. 6). If a study subscribes to the normative perspective, this would mean that a polycentric system of organisation would lead to WEF securities without compromising on the sustainability of natural resources. The analysis would then focus on the conditions that lead to the emergence of a polycentric WEF governance system. This would then be analogous with the recommendations of the huge body of research conducted on governance of local common pool resources which is implicitly based on the normative polycentric theory (E. Ostrom, 2005; Thiel et al., 2019).

Positive polycentricity theory “posits specific causes that help to explain governance structures, actors’ behaviour and performance of governance” (Thiel, 2016, p. 11). Therefore, using positive polycentricity theory would mean that we test the claims that the normative theory makes in terms of its performance besides testing its causal conditions. According to Blaikie (2000), an analytical framework consists of a family of theories that

adhere to common underlying assumptions making them internally consistent. The building blocks of polycentric governance described in a concept constitute an analytical framework including its desired hypothetical performance (Thiel, 2016). There have not been many studies on governance using polycentricity from a positivist perspective. However, E. Ostrom's Institutional Analysis and Development (IAD) framework (1990) is one such analytical framework, which has spawned a rich body of studies on the self-organisation capacities of communities in managing the local common pool resources. Thiel (2016) views IAD as a framework that operationalises polycentric governance theory through its focus on self-organisation. Self-organisation is one of the possible organisational forms in polycentric governance systems. From a normative perspective, van Zeben (2019, p. 6) mentions that "polycentricity is (in essence) the expression of a system's capacity for self-governance, which over time will give rise to a complex system of governance institutions".

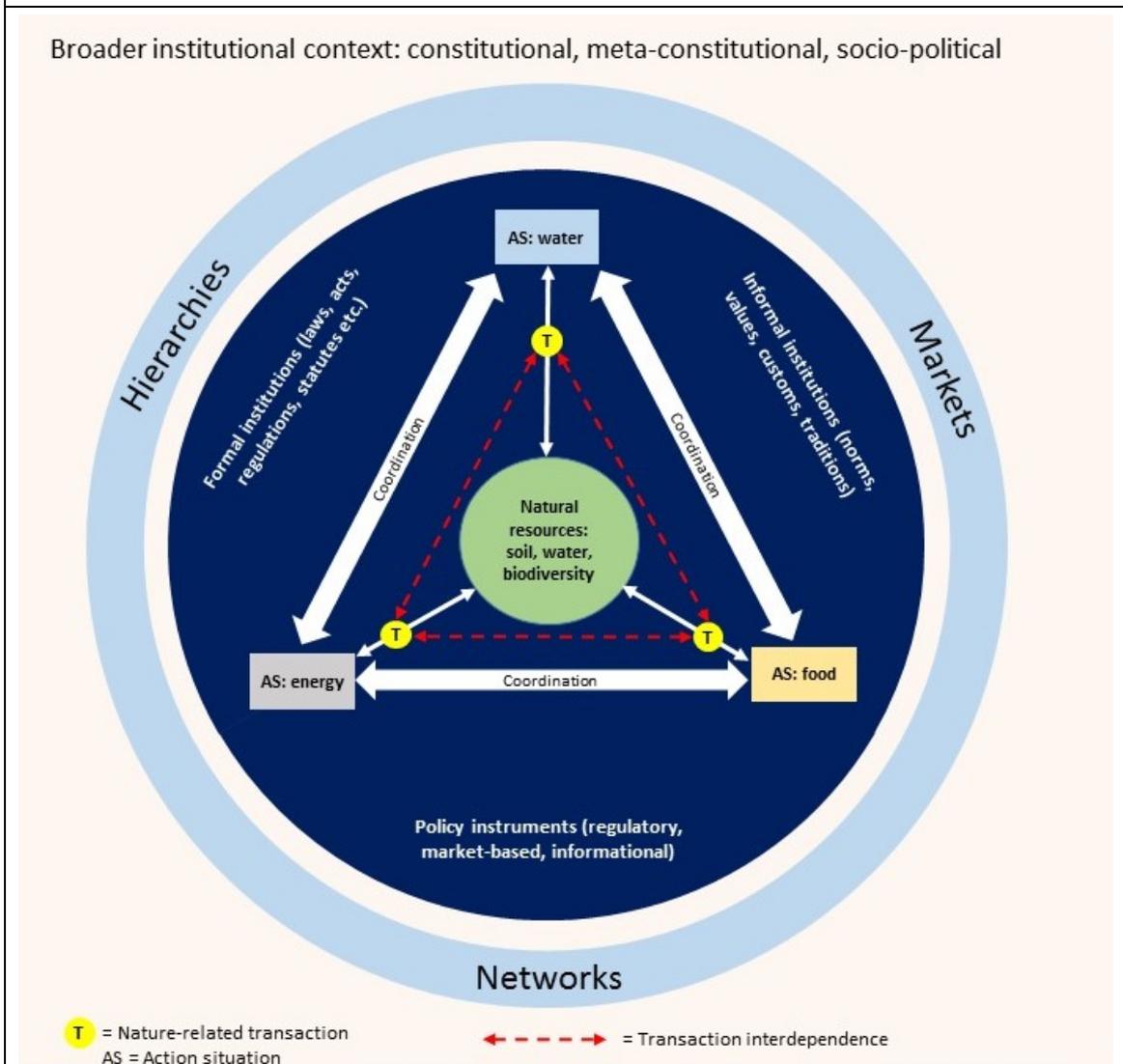
Owing to the origins of polycentric theory, which rose to prominence as a critique of the dichotomy of "state versus market" in mainstream economics literature, several attributes (especially cooperative or collaborative forms of organisation) were ascribed to polycentric systems, which were observed in the field. Gradually, evidence piled up proving the existence, efficacy and efficiency of other forms of coordination than state and market, namely mostly networks of cooperation for public good provision. It is therefore understandable that these normative notions of polycentrism began to take centre stage in the literature on polycentric governance systems. From an analysis of water governance in 29 river basins, Pahl-Wostl and Knieper (2014) argue that polycentric systems perform better in terms of climate change adaptation.

There is also a danger of ad hoc prescriptions of polycentric governance systems as a recipe for solving all governance problems. This is in fact pervasive in literature. It is important to inquire further into the performance of polycentric systems by posing questions on the conditions under which polycentric systems are effective, efficient, accountable, and representative in achieving the common social, economic and ecological goals. For this reason, it becomes imminent to embrace the polycentric approach from an analytical perspective. This will help to disentangle the various elements of the concept as well as to construct and test hypotheses on the relations among elements using multiple theoretical perspectives. In their editorial for a special issue, Heikkila, Villamayor-Tomas, and Garrick (2018) call for a positive analytical perspective on polycentric governance systems for environmental governance. They mention that only pure centralised or decentralised systems, which are ideal types and elusive in practice would fall outside the polycentric space. Measurement of features and variation across polycentric systems are affected by the binary view of polycentricity: whether a system is polycentric or not. As against this conception, polycentric systems exist in multiple designs and functional forms. They further identify an empirical bias in the scholarship of polycentric systems towards a focus on traditional common pool resources (CPRs) which therefore excludes the interactions across sectors from its analysis (Heikkila et al., 2018).

For a positive analysis of WEF governance, we propose to start with an ontological description of different elements that are to be included in the analysis: namely, key decision-making units/centres; key resources of focus; institutions (formal and informal); possible modes of governance; and how these elements are related with each other. These elements form the constituents, or building blocks, of the analytical framework that could be applied as a heuristic to assess the performance of the various arrangements in the

governance as observed in various empirical settings according to desirable performance/evaluative criteria. It is our belief that the provision of WEF securities is generally organised in different sectors with differing and sometimes overlapping sets of actors, who organise and make decisions in different, but interdependent, action situations on the use and management of natural resources, especially water, soil and biodiversity, for either independent or joint provision of water, food or energy. Although, these action situations are formally independent, their dependence on the same natural resources make them functionally interdependent. Thiel and Moser (2019) mention that, in the realms of management of water or other natural resources, functional interdependence means that governance and its performance are affected by a multitude of activities. These decision-making centres or action situations for water, energy and food provision are embedded in an overarching system of constitutional and meta-constitutional rules. Figure 1 presents a description of polycentric arrangements of WEF nexus governance.

Figure 1: WEF nexus governance – a conceptual framework



Source: Authors

3.2 A conceptual framework for WEF nexus governance

The purpose of constructing this conceptual framework is two-fold: First, it describes our view of how different components of WEF nexus governance are interlinked in polycentric systems. Second, it helps to operationalise the concept of polycentric governance and to test various hypotheses relating to the factors determining performance of governance in achieving WEF securities and understand the interdependencies. The framework serves as a heuristic to pose questions about the characteristics of different actors in different action situations providing and consuming public/collective goods through their nature-related transactions, attributes of resources, and other processes such as coordination for providing either goods and services or rules for providing them.

3.2.1 Natural resources as “common pool” resources

Natural resources (especially water, soil and biodiversity) are at the core of the nexus on which the WEF securities depend. Water in particular is crucial for the production of food and energy, as well as for fulfilling the drinking and sanitation needs of humans. Similarly, soil and biodiversity are vital inputs for food production. Generating energy requires water and, in the process, can degrade biodiversity, water and soil resources if environmental and social safeguards are not enforced. Attributes of natural resources play a very important role in understanding the use patterns of differing actors for different purposes (E. Ostrom, 1990). For instance, incentives for the appropriation of resource units are based on the attributes of rivalry and excludability of the resources. Water – be it surface or groundwater – is a classic “common pool” resource where high levels of rivalry exist, meaning that one actor’s use diminishes the quantity or quality of the resource for another actor. At the same time, options for excludability are typically low. Hence, sustainable water extraction requires some institutions that increase excludability. Mentioned in the literature are several other attributes of resources – for instance, size, location, predictability, and so on – that play a crucial role in determining the type of institutions that are suitable for sustainable management and use of water with different degrees of effectiveness. (Agrawal, 2003; Birner & Wittmer, 2004; Epstein, Vogt, Mincey, Cox, & Fischer, 2013; E. Ostrom, 2005).

3.2.2 Institutions

Institutions are recognised as an important component of a society, structuring a majority of interactions within that society (Hodgson, 2007). Although social structure may include relations that are not necessarily governed by rules, for a vast majority of social relations institutions – in the broadest understanding of the term (for example, as norms) – exist. Institutions as broadly defined by North (1993, p. 15) are “the constraints that human beings impose on human interaction. They constitute of formal rules (constitutions, statute law, common law, and regulations) and informal constraints (conventions, norms, and self-enforced codes of conduct) and their enforcement characteristics.” This definition and the various constituents of institutions point to their diversity and to the levels at which they can exist. In short, it can be understood that institutions constrain almost each and every action of an individual which involves at least one other individual, either directly or indirectly. Together with the standard constraints of economics, institutions define the so-called opportunity set in the economy.

Institutions are widely classified as formal and informal. Formal institutions are those institutions, which are most often defined in written form and consciously adopted. Formal institutions are generally provided, protected and enforced by the state, while deliberations may be held to secure public opinion prior to their enactment (Schmid, 2008). Economic development powered by intensive use of natural resources creates competition among rival users. In order to (re)design institutions that facilitate behaviour in support of sustainable resource use, a sound understanding of property rights institutions, their distribution and enforcement is crucial (Barzel, 1997; Bromley, 1991). Adopting policies without proper information on how the existing institutions condition actions, and thereby their consequences, can lead to disasters that can be social, economic or environmental in nature.

E. Ostrom (1990) distinguishes between three different levels of rules: operational choice rules; collective choice rules; and constitutional choice rules; together these affect the actions and outcomes in the management of common pool resources. There is a certain hierarchy in these different rules where the set of rules at a lower level is nested in and influenced by the set of rules at a higher level. *Operational choice rules* are the working rules which constrain the actions of individuals in an operational situation directly affecting the physical world. They govern the decisions of actors who directly interact with natural resources and regulate appropriation and provision of the resource as well as monitoring and enforcing the rules (E. Ostrom, 1990).

The operational rules are affected in turn by the actions at the level of collective choice which are constrained by a different set of *collective choice rules*. The main actors involved at this level include appropriators, in most cases an external agent such as an official who has the requisite power to frame the rules at operational level. *Constitutional choice rules* indirectly affect the operational rules through their effect on collective choice rules. Actors at this level, who are usually representatives of appropriators, higher authorities, and sometimes the appropriators themselves, assign rights and responsibilities of designing and enforcing operational choice rules to actors at the collective choice level. However, there is a possibility for individuals with self-organising capabilities to switch back and forth between different levels (E. Ostrom, 1990, p. 50). This nested nature of institutions is one of the basic principles of polycentric systems of governance.

3.2.3 Actors, action situations and network of adjacent action situations (NAAS)

An action situation as defined by E. Ostrom (2011, p. 11) is “an analytical concept that enables the analyst to isolate the immediate structure affecting a process of interest to the analyst for the purpose of explaining regularities in human actions and results...”. It consists of sets of actors or actor groups, specific positions that are ascribed to the participants, their choices, and their outcomes. In accordance with E. Ostrom’s (1990) three levels of analysis – operational, collective and constitutional choice levels – action situations at different levels have different sets of (sometimes overlapping) actors, are influenced by different sets of rules, and may produce different outcomes. Generally speaking, the rules that influence actions at the operational choice level action situations are provided by the action situations at the collective or constitutional choice level.

Referring to the seminal work of V. Ostrom et al. (1961), McGinnis (2011, p. 52) states that “key functions of polycentric governance implemented at the operational levels include

production, provision, financing, coordination and dispute resolution. Each of these activities constitute[s] an action situation in its own right". Hence, we expect to find these various different governance functions delivered by distinct action situations of the WEF nexus in the adapted NAAS framework. McGinnis (2011) further expands the action situation concept to include those adjacent action situations, which have a bearing on the actions of the focal action situation, thus proposing another useful analytical framework for operationalising polycentricity analysis, the network of adjacent action situations. He states that "an action situation X_i is adjacent to Y if the outcome of X_i directly influences the value of one or more of the working components of Y " (McGinnis, 2011). While in natural resource governance, the outcome of the focal action situation is usually physical in nature, in terms of change in quality or quantity of the resource in focus, the outcome of the adjacent action situation could be physical or institutional in nature. If the focal action situation is production of food and the action results in reduction in the quantity and quality of water, the adjacent action situation could be an organisational arrangement where new rules are made regarding restrictions on fertilizer application which will constrain the actions in the focal action situation. On the other hand, if the adjacent action situation focuses on actions for the production of bioenergy crops or withdrawal of water for thermal power generation, the resulting outcome of that action situation would alter the physical working component of the focal action situation.

The adjacency of action situations varies across contexts and nexus issue of focus. Some adjacent action situations (for example, some of the basic governance functions mentioned by V. Ostrom et al. (1961)) could actually occur in action situations which are spatially remote from the focal action situation. However, they may still have a significant influence on the focal action situation. Subject to the empirical context and research objectives, analysis of WEF nexus governance must select the focal action situation and adjacent action situations that are identified as having the strongest influence on the choices of decisions in the focal action situation.

3.2.4 Transaction interdependence and the need for coordination

The pursuit of WEF securities by actors in multiple, autonomous decision-making centres fundamentally involves biophysical transactions between the respective actors and natural resources for the production of water for consumption, food production or energy generation. Hagedorn (2008) considers "nature-based transactions" and the interdependence they create as crucial determinants of institutional and governance arrangements that emerge or are suitable to be designed. While the concept or the focus on transactions as a unit of analysis is borrowed from industrial organisation, originally defined by Oliver E. Williamson (1987), Hagedorn (2008, p. 360) defines nature-based transactions as "economically relevant processes by which goods and services, resources and amenities, damages and nuisances are allocated". He posits that transactions of goods caused by decisions made by actors usually also impact other actors positively or negatively, although they are not involved in the decision (Hagedorn, 2015). He further argues that, if the focus of the normative governance framework is to identify and promote institutions and governance solutions to achieve sustainability, then the physical properties of the nature-related transactions play a determining role and need to be considered in the analysis. Actors are the causal connection between transactions and institutions. Therefore, to understand

the interdependence, it is important to study both the physical as well as social interdependence between actors or organisations (Hagedorn, 2015).

When the transaction of one actor affects another actor negatively, the latter actor is likely to perceive the interdependence and enter into negotiations with the actor initiating the transaction. These negotiations may then lead to the design or changing of certain rules. This means that the need for coordination among actors in interdependent action situations may arise as a result of the transaction interdependence. From a New Institutional Economics perspective, Oliver E. Williamson (1979, pp. 241-242) argues that complex recurring transactions require long-term relations between identified individuals. In other words, actors are more likely to engage in institution-building within a hierarchical organisation rather than in an “anonymous market”. He further suggests that “governance structures” are needed to “attenuate opportunism” and infuse confidence in the economic transactions among self-interested actors. However, Granovetter (1985, p. 77) argues that all behaviour – including economic transactions (within and beyond organisations) – are embedded in social relations (networks). In other words, the structures of coordination in a governance system are embedded in a broader social, political, and cultural context and their effectiveness depends on such a context.

3.2.5 Coordination among decision centres/action situations

Scholarship relating to the WEF nexus is quite unanimous in its calls for more and effective coordination across sectors and multiple levels for governance of WEF nexus interlinkages (Pahl-Wostl, 2019). In governance literature, coordination and cooperation are often used in combination and sometimes even interchangeably. Hence, before we delve into the conditions and degrees of coordination, it would be worthwhile to provide conceptual clarity as to how we understand the terms. “Coordination” does not necessarily mean the same as “cooperation”. It is just an orderly arrangement of interdependent activities of different and autonomous decision-making centres. Coordination may or may not be achieved through voluntary actions of the constituents. There could be a central authority that devises rules for coordination, which may be based on the principles of coercion, competition, or cooperation. Where the agreed upon rules are jointly designed and enforced by the constituent decision-making centres, such interaction can be termed as cooperation. Coordination ensures synchronised activities and smooth functioning, but not necessarily the defining, agreeing and achieving of a common goal. Although lack of coordination may lead to chaos, a lack of cooperation may not *necessarily* lead to chaos, but there could be imbalanced representation of interests. Cooperative forms of governance open up the space of governance to non-government actors who together with other actors may work together towards achieving shared goals (Koontz & Garrick, 2019).

Coordination is an essential element of a polycentric governance framework. In fact, the purpose of a governance mechanism is to facilitate the coordination of interactions among constituent autonomous decision centres. However, in the relevant literature, polycentric systems are often associated with effective coordination in combination with the decentralisation of power. Pahl-Wostl and Knieper (2014, p. 140) define polycentric governance systems as “multiple centres of authority and distribution of power along with effective coordination structures”. Based on the degree of centralisation of power and the degree of coordination, they categorise governance regimes into four categories:

centralised-coordinated; centralised rent-seeking; fragmented; and polycentric. They then associate polycentric systems with positive outcomes, namely, increased resilience against shocks and as supporting experimentation and learning (Pahl-Wostl & Knieper, 2014). However, from a positive analytic conceptualisation, we define polycentric systems more liberally as being multiple decision-making centres with varying levels of authority and access to power resources and a variety of (coordination structure) interactions which may, or may not, be effective and efficient in achieving social, ecological and economic outcomes.

Another important contractual relationship through which different decision centres in a polycentric system take each other into account is *competition*. It is also argued by economic liberalists as an efficient form of interaction for producing public goods in a polycentric system as it results in the emergence of markets (Koontz & Garrick, 2019). Koontz and Garrick (2019, pp. 111-114) further describe three factors that provide incentives for engaging in different interactions between each other: authority, information and resources.

Authority defines the limitations of different decision centres allowing them or forbidding them to take particular actions or entering or exiting particular interactions with each other. In the public sector, authority is usually assigned or devolved by a higher constitutional authority. Devolution of authority is an essential element of various decentralisation strategies pursued in different parts of the world, involving both responsibility as well as constitutionally backed power to make decisions regarding production as well as social, political, legal transactions with respect to a specified policy area and jurisdiction. Effective decentralisation of authority may guarantee the formal autonomy of a decision-making centre which is an important attribute of polycentric systems of governance. Authority may facilitate competitive, cooperative as well as regulatory contracts among decision centres. Which interactions emerge further depend on other conditions of access to information and resources.

Information on the costs and benefits of alternative production mechanisms for public goods, externalities, and transaction costs are crucial if actors in different action situations are to decide on alternatives of production or interaction with other actors. Information on the roles and responsibilities of the various different actors is helpful in increasing the accountability and transparency of the governance process.

Access to financial, human and natural *resources* is vital to carrying out the assigned or agreed upon roles and responsibilities in generating public goods or monitoring the provision of goods and services. Distribution of access to key resources also defines the power relations among actors in a governance system. Actors with a shared mandate may enter into cooperative relationships of sharing resources and complementing each other in achieving shared goals.

The types of interactions or coordination mechanisms that emerge in a given context depend on the distribution of authority, information and resources across decision centres. There are opportunities for all three kinds of interactions, competition, cooperation and coercion to occur in a system where multiple centres exist under a common set of overarching rules (Koontz & Garrick, 2019). How the three vital elements are distributed among differing actors and decision centres is further contingent on the social, political and cultural contexts.

Social structures, or relationships in which the interactions among actors are embedded, provide some insights into the opportunities and constraints faced by actors in making their choices between possible interactions or coordination with other actors (Stein et al., 2018).

Stein et al. (2018) assert that three forms of embeddedness create conditions for coordination and cooperation through multiple network mechanisms at different network levels – namely positional, relational and structural. While a network approach can “unpack” power relations to some extent by identifying powerful actors in terms of their centrality, it is not sufficient to explain the cultural, historical and political context crucial to the understanding of the meanings and dynamics of social networks. “Power and justice” affect interactions, outcomes and performance in a governance system. In consequence, political dimensions need to be better integrated: Skelcher (2005), for instance, suggests integrating polycentricity theory with the theory of democracy as one useful approach.

3.2.6 Governance modes and policy instruments

Governance modes are organisational solutions aimed at making the institutions or rules effective (Hagedorn, 2015) in realising different purposes of governance. Different ideal types of governance modes such as networks, markets and hierarchies exist and are based on the principles of cooperation, competition or coercion. Pahl-Wostl (2017) posits that coordination for managing the interactions in the provision of water, energy and food securities requires a combination of networks, markets and hierarchies. In order to internalise the externalities of nature-related transactions, specific policy instruments are required. Further, policy instruments require suitable governance modes for their effective implementation. Which modes of governance promote coordination for internalising the externality costs effectively depends on the properties of the transactions (as discussed in the earlier section) as well as on meta-institutions which create the enabling environment for actors at operational and collective choice levels to make rules.

Actors in a polycentric system usually evaluate the performance of the decision-makers in different centres of decision-making against certain performance criteria (efficiency, control, political representation, accountability) and – if they are continuously affected negatively – might exit from the relation or switch to alternate arrangements (Thiel, 2016). The choice of governance mode also depends on the type of goods and how the property rights to the resources and their ecosystem services are defined. In the case of high rivalry and a lack of excludability, a market mode of governance may not be a feasible option, but other forms of governance such as networks or hierarchy may work.

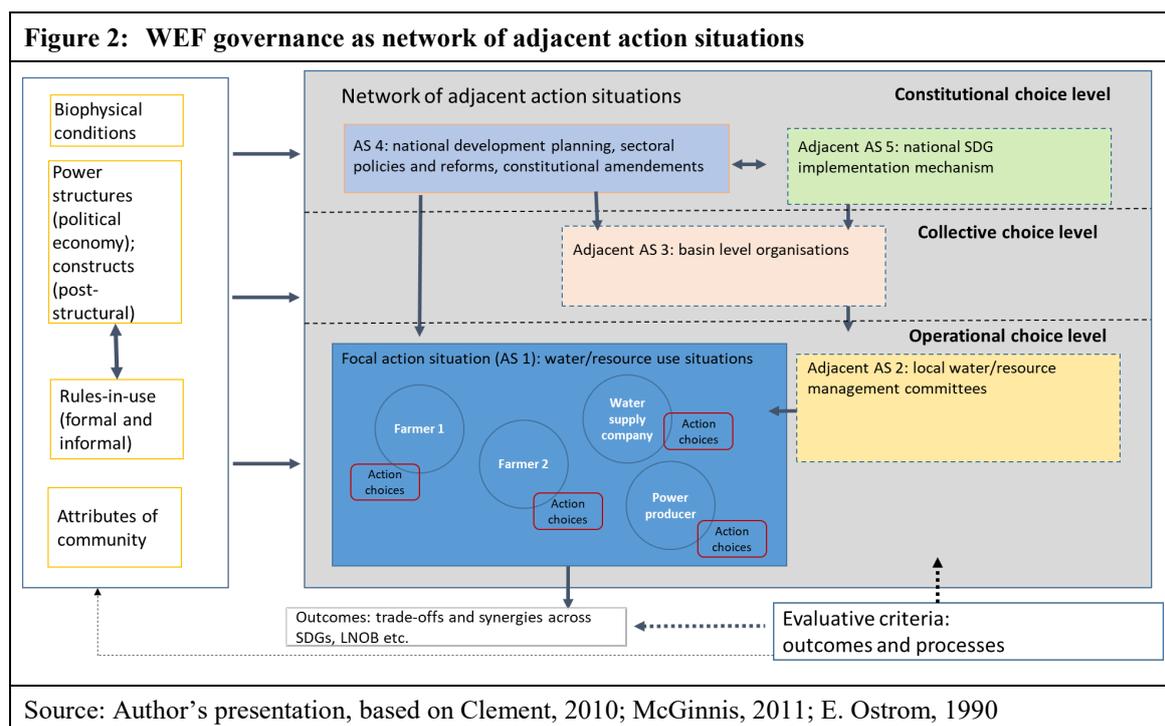
Pahl-Wostl (2019) argues that a combination of different governance modes – collaborative networks, market-based approaches and regulatory frameworks – is essential for achieving coordination among different decision-making centres. Hybrid governance forms, combining two or more governance modes, are purposefully designed structures and may be manifested in different types of policy instruments that are used to achieve a policy goal (Pahl-Wostl et al., 2020). Especially in irrigation management, combining hierarchical irrigation system governance with participatory irrigation management (Newig, Derwort, & Jager, 2019) or farmer-managed irrigation system (FMIS) emerged as an “institutional panacea” in the 1990s (Gandhi, Johnson, Neog, & Jain, 2020; Meinzen-Dick, 2007). Further, Leininger et al. (2018) emphasise the role of combining various different governance modes for governing the interlinkages among WEF-related SDGs as the following three cases illustrate. A combination of voluntary agreements between water supply companies and formal regulations (namely, the German Drinking Water Directive and EU Nitrate Directive) were initially successful in adopting sustainable production

practices and reducing nitrate leaching (see Richerzhagen & Scheumann, 2016). Later, a parallel promotion by the European Union and Germany for biomass and renewable energies offset these positive effects. Similarly, a market-based mechanism that was implemented in the Hidrasogamoso hydropower plant in Columbia was only sufficient in compensating the upstream farmers for conservation of biodiversity as well as preventing the sedimentation of the reservoir. On the other hand, the mechanism did not compensate the losses of the downstream water users who had less water available for food production (Rodriguez et al. 2019). Therefore, a hierarchical arrangement to ensure that the principle of “leave no one behind” (LNOB) would need to be integrated into the governance of water resources for energy and food production in the Columbian case. Similar observations were made pertaining to the need for the hierarchical mode for sequentially reforming the water and energy sectors in order to provide the right incentives for private actors to participate in waste water treatment in India (Never & Stepping, 2018). Hence, it is clear from the above examples that no single mode of governance will be sufficient to achieve all the three securities of the nexus and not exclude any interest groups from the benefits.

Policy instruments to facilitate or constrain an action towards achieving a desirable outcome – in this case one of the WEF securities – need to be evaluated not only for their impact on the provision of the intended collective good but also in how far they impact the provision of other goods of interest. Going by the famous Tinbergen’s (1952) rule that each policy target should be matched with one tool, there is a need to check for the interactive effects among policy goals, among tools or policy instruments that may belong to different sectors or levels of the government (Del Rio & Howlett, 2013). Del Rio and Howlett (2013) further note that it is difficult to achieve horizontal and vertical coordination at the same time. This is because of the existence of different goals at different levels of administration and is moreover a result of the non-uniform distribution of costs and benefits across levels, which creates “winners and losers” for each instrument. The different logics of policy instruments and different principles underlying the different modes of governance may sometimes lead to conflicts instead of synergies making a particular combination incompatible and thereby inefficient in achieving the policy objectives (Pahl-Wostl et al., 2020). For example, in the Indian irrigation systems, Mollinga, Meinzen-Dick and Merrey (2007) noticed that reluctance on the part of central and state agencies to devolve power to water user associations (WUAs) did not provide incentives for the participation of water users and that this explained the varied and limited success of the particular combination of hierarchy and network modes of governance. For this reason, the context-based assessment of possible interactions both within and beyond policy mixes, based on the underlying principles, is crucial for their effectiveness in achieving the intended policy goals.

3.3 Illustrating networked adjacent action situations for WEF nexus analysis

Following the introduction of the action situation and its components in an earlier section, we would now like to present an illustration of adjacent action situations, the level at which they might occur, the interlinkages among different action situations, and the external factors affecting the choices of actors and in turn their outcomes (see Figure 2).



In the context of the WEF nexus, the water abstraction (utilisation) situation is chosen as a *focal action situation*. This has direct resource-related as well as WEF security-related outcomes. The actors involved in this situation which occurs at the operational choice level are typically farmers who appropriate water for food/crop production; water supply companies withdrawing water for drinking water supply; and power producers using water for energy generation. The choices of actors, in terms of whether and how much water they withdraw from the source, and their choice of technology for water abstraction, are determined among other things by the operational choice rules which are a mix of rules devised in adjacent action situations either at the operational choice level or at higher levels. For example, there could be a local water management committee or water-user association which would devise and enforce rules of appropriation for water. This rule-making process is further legitimised on the basis of the constitutional provisions, broader policy goals or by a sector-wide water allocation and land administration regime (allocation, land-use change).

Within the context of SDG implementation, most countries have established SDG implementation/coordination mechanisms at least at the national level. These mechanisms are typically composite bodies constituted by representatives from different key ministries of the government and sometimes representatives of private sector, civil society and academia (Breuer, Janetschek, & Malerba, 2019). Such SDG implementation mechanisms could have a positive influence on the balancing of interests across ministries and spatial scales. In order to test this hypothesis, the forum or mechanism for SDG implementation could be included as an adjacent action situation where deliberations by representatives of various type of actors possibly take place which lead to decisions that influence action situations at either the same or lower levels. Another key set of action situations at the constitutional choice level are the sectoral ministries, which design the collective and operational choice rules crucial for focal action situations.

The choices of action in different action situations (focal and adjacent) are further constrained by the external context which as per the original IAD framework consisted of

three elements, namely, attributes of resources, attributes of community and rules-in-use (E. Ostrom, 1990). Sections 3.2.1 and 3.2.2 have already introduced the various attributes of resources as well as rules-in-use. Attributes of the community such as heterogeneity, size, and level of trust determine mainly the capacity to coordinate and solve social dilemmas in different action situations (Agrawal, 2003).

The outcomes of different action situations feed back into other action situations within the network. This feedback is in the form of resource flows, institutional/rule flows and information flows which define the conditions under which decisions are made in action situations. The performance of the governance system is evaluated on the basis of criteria of outcomes as well as of processes. Outcomes typically include effectiveness and efficiency of coordination mechanisms in achieving the shared goals. In the context of achieving WEF nexus-related SDGs, the outcomes could also be trade-offs avoided among contextualised goals and strategies. Further, adherence to the 2030 Agenda's core principle of leaving no one behind could also be an important outcome criterium for assessing the performance of WEF nexus governance. Processes in achieving the shared goals should also be part of the evaluative criteria, which include accountability, due representation of interests of all actors and actor groups concerned, and opportunities for social learning provided by the governance processes. A relatively important process criterion for assessment is the adaptability of the governance system to deal with external shocks such as climate change-induced extremities or economic shocks.

3.3.1 “Power” in the analysis of polycentric WEF nexus governance

The literature review provided earlier points to the lack of attention that has been paid to the role of power relations in WEF nexus research. It is hence crucial to understand the role of power (its various different manifestations) in achieving coordination. In this respect the IAD framework has been criticised for the fact that the decisions of actors and their outcomes are often explained with recourse to rules and that this often ignores the role played by power dynamics in shaping institutions (Cleaver, 2000; Clement, 2010). Although the IAD provides a solid basis for multi-level analysis through its conceptualisation of nested action arenas and governance levels, it does not sufficiently capture the influence of intra- and inter-level power distribution on institutional design and effectiveness (Clement, 2010). The effects of power asymmetries, which are more widespread in the less industrialised societies, are spread across multiple and interlinked social and political arenas (Kashwan, 2016).

Increasing efforts have been made to address this gap by integrating the approaches of political ecology to understand the critical role of power in environmental governance into the institutional analytical approaches. The broad conceptualisation of institutions as “prescriptions that humans use to organize all forms of repetitive and structured interactions including those within families, neighbourhoods, markets, firms, sports leagues, churches, private associations, and governments at all scales” (E. Ostrom, 2005, p. 3) allows for the integration of power relations as one of the conditioning institutional processes leading to particular political outcomes (Bennett, Acton, Epstein, Gruby, & Nenadovic, 2018; Clement, 2010). Bennett et al. (2018) develop a relational typology based on the antecedent and consequent relation between power and institutions as well as political economic and post-structuralist conceptualisations of power that are prevalent in political ecology approaches.

The political economic “power structures” such as capitalism, class, gender, and so on are based on the premise that power resides in stable societal structures that determine control over, and access to resources. In contrast, post-structural “power constructs”, such as discourses, narratives, power/knowledge, subjectivities etcetera, influence individuals and groups in their operations as well as shaping the reality (for instance, environmental problems) (Bennett et al., 2018). The authors further mention that post-structural power constructs provide a methodological approach to studying how the social norms and internal values emerge and change. Based on the relational typology developed by Bennett et al. (2018) for understanding the relationships between power and institutions, we can formulate a range of research questions about relationships between operationalisable concepts of institutions, power structures and power constructs.

4 Methods for analysing WEF nexus governance

Conceptualisations of polycentric governance as a framework for analysis focus on how particular arrangements among different entities in the framework influence the performance of the governance (Thiel, 2016). There have been several analytical frameworks to operationalise polycentric theory, prominent among them being the IAD framework, which has widely been used to study self-organisation. A wide variety of methods – namely small-N case studies; comparative field-based research; meta-analysis; laboratory and field experiments; agent-based modelling – have been used in combination with the IAD framework (Poteete, Janssen, & Ostrom, 2010). Almost all of the studies focused on single action situations and single collective/public good of interest.

Following the enhancement of the IAD framework to include the adjacent action situations along with the focal action situation (McGinnis, 2011), a few authors have started to explore new combinations of methods to analyse the interactions among different action situations and thereby offer a more complete explanation of the choices and outcomes of the focal action situation. Kimmich (2013) employs a combination of NAAS and Ecology of Games (EG) frameworks to understand the coordination dilemmas of the interlinked energy and water systems in India. Villamayor-Tomas et al. (2015) employ a combination of NAAS and value chain frameworks to understand similar interlinkages in Spain. Both studies relied on quantitative and qualitative data obtained from primary and secondary sources. Both Ecology of Games and NAAS approaches go beyond the normative focus about the virtues of polycentric governance and mere descriptions of action situations (in NAAS) or policy games (in Ecology of Games). They are helpful in generating empirically testable hypotheses about the structure of the game or action situations, analysing the drivers of individual behaviour and institutional change and showing how these lead to policy outputs and outcomes (Lubell, 2013).

Unit of analysis/boundary of adjacency: One of the initial and crucial tasks in a WEF nexus study is to identify the relevant focal action situation and adjacent action situations. This essentially depends on the research question and the WEF issues that the research project is focusing on. There can be numerous adjacent action situations surrounding the focal action situation. However, the selection should depend on the theoretical proposition and the empirical knowledge (Kimmich, 2013) gained through exploratory field research approaches such as secondary data, review of the literature, and interviews with key actors.

Stein et al. (2018) use the concept called “problemshed and issue network”, originally proposed by Mollinga et al. (2007) in selecting a unit of analysis. This concept moves beyond a pre-defined geographical unit of analysis (such as a watershed) or a sectoral focus (for instance, water) to include a broad set of issues that are linked to the context of a problem. “Problemshed” is framed through an iterative process by the researcher, or co-constructed with stakeholders. The specific issues of WEF nexus interlinkages as a framework can guide in framing the problemshed.

Understanding networks: Network theory and analysis is increasingly being used to disentangle the complex interdependencies in polycentric systems. Social network analysis (SNA) is a tool to understand the characteristics or structure of a network by identifying the actors involved in a network and their relationships. This approach helps to understand how social relationships shape governance processes and provide opportunities and constraints for addressing complex and interconnected sustainability challenges (Stein et al., 2018). The centrality of different actors and actor groups is determined and influential actors with a bridging position are identified. Whether the understanding could be extended to the functionality of the networks is a question that is not fully explored in current studies (Lubell, 2013). Relational data generated from the network survey can be transferred into adjacency matrices representing various issue networks identified on the basis of the concept of problemshed and issue networks (Mollinga et al., 2007) mentioned above. These issue networks could also be based on the action situations identified on the basis of the NAAS framework.

SNA relies on primary data collected from actors who are participants in selected action situations through a structured network survey questionnaire which focuses on the positional, relational and structural attributes of the network embeddedness. Alternatively, “net map” is a method to determine the network in a participatory approach (Schiffer & Hauck, 2010).

Going beyond the quantitative SNA, semi-structured interviews with actors participating in action situations are useful to understand the considerations behind the decisions of actors as well as the structure of the action situation. Further, focus groups with groups of actors within an action situation are a useful technique to gather data on group dynamics and elicit particular kinds of historical or recent data, which are often found to be more reliable if they emerge out of a discussion among actors with similar interests.

5 Conclusions

The majority of the scholarship on the WEF nexus focuses on substantiating the biophysical interlinkages among the related sectors of water, food and energy. These help in understanding the magnitude of the problem in different contexts and in strengthening the case for integrated governance of the WEF systems. However, social, political and institutional interlinkages, crucial for understanding and evolving an integrated governance approach, have received less attention. This is the result of the dominant technical-managerial view of the WEF nexus problem within the research. The recent surge in analyses of the WEF nexus using the analytical approaches of environmental governance has emphasised the need for more and effective horizontal (cross-sectoral) and vertical (cross-level) coordination in order to avoid trade-offs and to achieve synergies in realising

WEF securities. However, prior literature falls short of explaining the conditions under which such coordination occurs.

In our effort to further the WEF nexus governance research, we have conceptualised WEF nexus governance as a polycentric system. Further, we have argued that analysis of a polycentric WEF nexus governance system would help, first, to understand the relations and interactions among the constituent decision centres which we have conceptualised as networked adjacent action situations; and, subsequently, to investigate the conditions under which different types of interactions emerge among the decision centres. We then proposed a conceptual framework covering various components of WEF governance systems and their logical interrelations. The conceptual framework highlighted the need for coordination arising out of the interdependence of WEF-related transactions by actors in various different interlinked action situations.

Various different forms of coordination – namely cooperation, coercion and competition to manage the interdependencies in WEF nexus – are achieved through various means. Which type of interactions different decision centres engage in to coordinate their transactions is dependent on the way authority, information and resources are distributed among the decision centres. It was further argued that WEF nexus governance requires a combination of differing coordination mechanisms in order to manage the cross-sector and cross-scale interlinkages. The coordination mechanisms of hierarchies, markets and cooperation are further embedded in the social structure or relationships, which facilitate or constrain coordination.

The proposed analytical framework based on the concept of network of action situations (an extension of the IAD framework) has the potential to operationalise the polycentric WEF nexus governance systems. The analytical framework provides a heuristic for formulating research questions relevant to the context and hypotheses related to conditions affecting the action situation and the interactions among action situations. Further, integrating the approaches from political ecology to understand the role of power structures and power constructs will support the inquiry into how power relations shape, and are shaped by, rules-in-use at various levels. The framework also allows one to assess the performance of the governance system based on outcome and process criteria defined in the respective context and the indicators suggested by theory.

Methodological innovation is called for in operationalising the analysis of polycentric governance systems in the context of WEF nexus. Instead of delineating action situations based on sectoral boundaries, we propose the application of the “problemshed” concept so that the analysis can be focused on the actual issues facing the coordination problem and so that the coordination can be assessed for its conditions and performance in solving the problem. A combination of approaches that study social networks as well as institutions, actors, and resource characteristics may complement each other in providing a holistic understanding of how a specific situation of WEF nexus governance is organised and performs.

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