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Research Article

An Assessment Framework for Integrated Food-Energy-Water Nexus Governance: Application to the Cases of Phoenix and Cape Town

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Abstract

Food-energy-water nexus governance has been promoted as an approach to integrate the management and policy of the three sectors together for coordinated governance. However, there are limited approaches to evaluate, assess, or measure the governance of the food-energy-water nexus. Assessment of the governance process is important to move the concept from conceptualization toward implementation and to understand the specific potential and

In this article

in practice. This theoretical framework is then applied to two example cases: Phoenix, Arizona, USA and Cape Town, South Africa. The implementation of this framework provides recommended factors needed for improved collaborative FEW nexus governance in cities. These cases showcase the utility of this framework in assessing urban collaborative food-energy-water nexus governance.

Q Keywords: Collaborative governance food-energy-water nexus integrated resource management natural resource management assessment

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Introduction

Governance of the food-energy-water (FEW) nexus entails a multi-sector and multi-scalar approach to policy, planning, and management, which considers the three resources and their interactions, tradeoffs, and co-benefits together in the decision-making process (Lele, Klousia-Marquis, and Goswami 2013; Bazilian et al. 2011). Scholars argue that a FEW nexus approach to governance can be beneficial for increased resource security and sustainability (Leck et al. 2015; Finley and Seiber 2014). Despite the benefits of integrated governance, decisions are often made in isolation, without coordination and communication across sectors (Leck et al. 2015). This lack of collaboration can inhibit goals toward sustainable resource management for food, energy, and water.

Research on FEW nexus governance has yet to produce an agreed-upon approach for measurement, evaluation, or assessment of its efficacy. We define FEW nexus governance assessment as judging the nature and quality of collaboration across the three sectors to better understand how the governance is integrated across them. Governance assessment is necessary to determine benefits of specific governance approaches in practice, to address critiques of FEW nexus governance approaches, and to provide guidelines for improvement (Conley and Moote 2003; Ferreyra and Beard 2007). This moves FEW nexus governance from

2018). While indicator assessment sets of the FEW nexus currently exist at the national scale (e.g., Yuan and Lo 2020) and the local scale (e.g., Biggs et al. 2015), most indicators focus on physical resource flows instead of assessment of governance structures. Thus, to our knowledge, a limited number of studies (e.g., Kurian et al. 2019) have developed comprehensive assessment frameworks or indicator sets with the explicit purpose of evaluating FEW nexus governance structures. This study seeks to address this research gap by creating a conceptual framework for assessment of collaborative FEW nexus governance and by showing how it can be operationalized using evidence from example case studies. Integrating the established theory of collaborative governance with the newer FEW nexus concept, this study presents a pathway to enhance FEW nexus governance, while providing a use-case for collaborative governance theory to address multi-sectoral resource systems.

Background

Food-Energy-Water Nexus

Food-energy-water nexus governance considers the process of integrated management, policy, and decision-making across the three sectors for coordinated governance approaches and achievement of shared outcomes (Weitz et al. 2017; Vogeler et al. 2019). This is important because many food, energy, and water decisions are made in silos without consideration of the cross-sector relationships and tradeoffs (Lebel et al. 2020; Lele, Klousia-Marquis, and Goswami 2013). The lack of coordination can result in incoherent policy and planning that can leave the system exposed to potential vulnerabilities, uncertainties, and external shocks. Incorporating systems thinking into FEW nexus governance of the urban system can enhance sustainability, reduce unintended consequences, and increase system resilience (Leck et al. 2015; Kurian et al. 2019).

Even with the proposed benefits of the FEW nexus approach to governance, there has been some critique. First, we must be careful not to consider the nexus as a panacea for all resource

resource security. For example, there could be reduced equality in resource access, especially as the dominant FEW nexus approach has limited explicit consideration of environmental justice within its framing (Allouche and Middleton [2015](#)). Additionally, other scholars have criticized the ambiguity of the term's definition and purpose (Endo et al. [2017](#); Smajgl, Ward, and Pluschke [2016](#)), while others have even called it a meaningless “buzzword” (Cairns and Krzywoszynska [2016](#)). Much of this ambiguity comes from limited methods for measurement and operationalization.

Several approaches have been created to measure, evaluate, and assess the physical resource flows within the FEW nexus. In a review by Albrecht, Crootof, and Scott ([2018](#)), the authors note that nearly three-quarters of FEW nexus studies use quantitative over qualitative methods and only about one-quarter of studies use social science approaches. The most common methods for assessing the FEW nexus employ environmental management modeling, economic analysis, and indicators (Albrecht, Crootof, and Scott [2018](#)). Indicator sets summarize and condense information into manageable units to analyze and understand the nature of a complex system (Singh et al. [2009](#)). They can be useful for policymakers as a set of coherent targets to monitor and manage resources, to improve policy development for resource security, and to promote the sustainable use of resources (Arthur et al. [2019](#)). Several studies have sought to create indicator sets to assess the FEW nexus (Yuan and Lo [2020](#); Biggs et al. [2015](#); Venghaus and Dieken [2019](#)) or adapt indicators from the Sustainable Development Goals (Bleischwitz et al. [2018](#); Fader et al. [2018](#); Liu et al. [2018](#)). Another study creates the Wastewater Reuse Effectiveness Index based on place-based agent-based modeling in Indonesia, including indicators and variables for both biophysical components and governance and socioeconomic components of the system (Kurian et al. [2019](#)). However, beyond this study, the majority of indicator sets still only evaluate the physical resource flows as opposed to governance processes and structures (Arthur et al. [2019](#)).

Collaborative Governance

Scholars have used a number of approaches to conceptualize governance. Here, we follow Pahl-Wostl ([2009](#)), who suggests an encompassing approach to governance that includes the

actor groups; (3) interactions across multi-level organizational boundaries; and (4) multiple modes of governance including markets, hierarchies and networks. Defined in this way, governance includes the full complexity of processes and interactions, as formulated and implemented by diverse state and non-state actors, to steer and/or coordinate resource use (Pahl-Wostl 2009). Resource management, a closely related but distinct concept, refers to the strategies and measures used to maintain the state of natural resources to achieve desired goals (Pahl-Wostl 2009). Governance failures are often present at the root of many resource management problems, and thus assessment of governance is critical in addressing resource mismanagement.

To improve resource management, collaborative governance is an approach to facilitate collaboration within public policy, management, and planning through the engagement of multiple actors and organizations across scales and sectors in the decision-making process (Emerson, Nabatchi, and Balogh 2012; Ansell and Gash 2007). Collaboration of various actors across different disciplines and administrative levels can improve credibility, legitimacy, and salience within the decision-making process, which can reduce vulnerabilities across the local natural resource system (Cash et al. 2003). The Institutional Analysis and Development (IAD) framework, developed by Ostrom (1990), provides an opportunity to better understand the governance of these resource systems, as it identifies the actors and interactions between them in managing common pool resources, centering around the action arena where these engagements occur. The IAD framework has contributed toward theory building and empirical applications within collaborative governance of natural resources, providing insight into the various factors needed for initiating and sustaining collaborative governance (Sullivan, White, and Hanemann 2019).

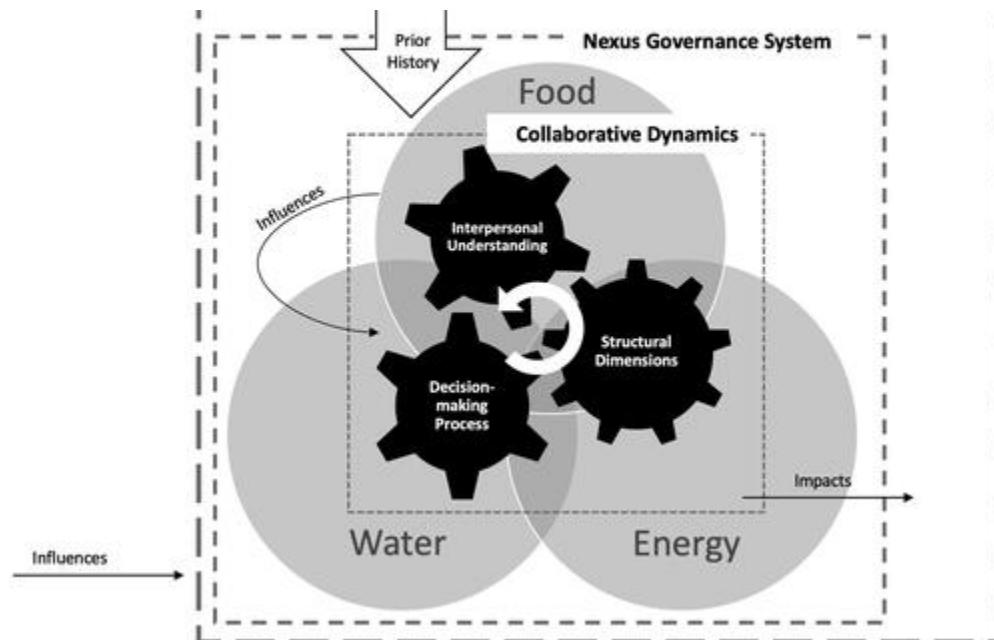
Prior research in measuring collaborative governance of natural resources has considered the impacts of collaborative engagement on outcomes in sectors such as forestry (e.g., Secco et al. 2014; Abrams et al. 2020), ecosystem conservation (e.g., Koontz, Jager, and Newig 2020; Muñoz-Erickson, Aguilar-González, and Sisk 2007), and water management (e.g., Ferreyra and Beard 2007; Huang et al. 2017; Biddle 2017). To understand the impact of collaborative governance processes, these studies have used a variety of assessment approaches, including social

2011), and indicator development (e.g., Abrams et al. 2020).

Conceptual Framework Construction

Our framework includes three core components, which each contains several concepts (Table 1) and a set of indicators for assessment (Table 2); these were constructed from a literature review. This framework builds upon and extends the Collaborative Governance Regime (CGR) framework (Emerson, Nabatchi, and Balogh 2012). The CGR framework conceptualizes collaborative governance components and has been used in empirical studies (e.g., Ulibarri 2015; Biddle 2017; Abrams et al. 2020). However, as the CGR framework was created with a focus on single-sector analysis, triangulating across multiple collaborative governance approaches from different disciplines and resource sectors allows for the creation of a new framework that can better address multi-sectoral systems. The CGR framework was thus used as an initial outline here, with modifications to represent local FEW nexus systems most adequately. Based on a targeted literature review of empirical studies and theoretical construction, we triangulated the literature to uncover the most common concepts of collaborative governance. When these collaborative governance concepts were integrated with the nexus, we produced a framework of FEW nexus collaborative governance (Figure 1). This conceptual framework consists of three main components that interact together across the sectors: structural dimensions, decision-making processes, and interpersonal understanding.

Figure 1. Conceptual framework for assessing collaborative FEW nexus governance.



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Table 1. The operationalization of the three key components of the conceptual framework.



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Table 2. Eleven concepts considered for assessing collaborative governance of the FEW nexus. Each concept includes a definition, identified indicator(s), measurement of those indicators, data type, and an example from the literature using this indicator (if applicable).



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Structural dimensions are defined as the socio-political arrangements between the sectors and the actors within the sectors, encompassing capacity for joint action in the CGR framework (Emerson, Nabatchi, and Balogh 2012). Structural dimensions include the five concepts of

and the formal and informal rules that govern them (Ostrom 1990). Clearly defined roles, rules, and responsibilities can help to increase the legitimacy of the engagement and are imperative for successful collaboration (Ansell and Gash 2007). *Actor inclusivity* refers to the inclusion of a diversity of actors and stakeholders in the collaborative engagement (Ansell and Gash 2007); this includes actors from across multiple governance sectors (e.g., public, private, nonprofit), levels, and resource sectors. It is important to capture a diversity of stakeholder perspectives within governance for a wholistic understanding of the system (Hoolohan et al. 2018; Pahl-Wostl 2009) and for true legitimacy of the collaborative process (Ansell and Gash 2007). *Intentional leadership* refers to the responsibility of empowering actors and bringing stakeholders together to move the engagement forward (Vangen and Huxham 2003). Leadership is important in overcoming power asymmetries, building trust, maintaining existing institutions, and mobilizing action for change (Ansell and Gash 2007; Folke et al. 2005). *Shared resources* are the finances, time, skills, personnel, and capital that are shared between sectors within the collaborative engagement to advance mutual goals (Emerson, Nabatchi, and Balogh 2012). *Knowledge sharing* is the information, data, and expertise that actors from different sectors bring to the collaborative governance engagement for use by all three sectors (Plummer et al. 2012). Collaboration provides an opportunity for resource-scarce or information-scarce organizations or sectors to leverage others' resources and knowledge through sharing (Thomson and Perry 2006), which can address asymmetries between sectors and organizations and increase organizational capacity (Ansell and Gash 2007).

Decision-making processes are the ways in which stakeholders within each sector evaluate alternatives and outcomes to make informed choices under specific contexts and uncertainties (Larson et al. 2015). Scholars often consider uncertainties as a given within human-environment systems (Pahl-Wostl 2009; Folke et al. 2005), and complex systems, such as the FEW nexus, require the consideration of system uncertainties within the decision-making process (Larson et al. 2015). Yet different groups can have different perspectives on uncertainty (Jacobs, Garfin, and Lenart 2005; McNie 2007), which can present challenges for coordination and collaboration in an uncertain world (White et al. 2015). Complementary decision-making approaches are thus important for successful collaborative governance. Encompassing principled engagement from

decision-making, partnership, and problem solving over time. This component includes three concepts: shared goals, open communication, and power balance. *Shared goals* include the sectors having common desired outcomes from the engagement, which may include having a shared vision, purpose, or objective between them. This allows all the stakeholders to be on the same page about the intention of the collaborative engagement and to have a shared understanding of the potential benefit from collaboration. *Open communication*, the respectful dialogue between stakeholders across the sectors, is a necessary characteristic for successful collaborative governance (Medema et al. [2017](#); Yeboah-Assiamah, Muller, and Domfeh [2016](#); Porter and Birdi [2018](#)). This should include negotiation, discussion, and listening across sectors (Newig et al. [2018](#)). *Power balance* refers to the distribution of authority and influence among sectors or intentional efforts to understand and overcome power differences within the collaborative engagement, as unchecked differentials in power can challenge collaborative engagement if powerful actors manipulate the process for their own gain (Ansell and Gash [2007](#)).

Interpersonal understanding focuses on the relational elements within the collaboration and provides a needed foundation of common understanding or agreement for coordination that must be established before or in the beginning stages of an engagement. This component encompasses shared motivation in the CGR framework, as it focuses on the interpersonal and relational elements of collaborative governance (Emerson, Nabatchi, and Balogh [2012](#)). Interpersonal understanding includes the three concepts of trust, commitment, and shared values, which are needed for successful FEW nexus engagement (Kliskey et al. [2021](#)). The concept *trust* here includes both current trust and trust building efforts; this concept refers to the condition of having belief in another's goodwill across the sectors or to the process of building increased trust for engagement. Trust has been found to be a foundational component of successful collaborative governance in theoretical literature (Ansell and Gash [2007](#)) and empirical studies (Sullivan, White, and Hanemann [2019](#); Schoon et al. [2017](#)), as it enables stakeholders to take action toward collective goals under the expectation that others will also do their part (Emerson, Nabatchi, and Balogh [2012](#)). *Commitment* to the process refers to stakeholders across sectors choosing to engage in and being dedicated to the process with the

do not see the collaborative benefit as better than that of individual action. *Shared values* include the sectors having similar perspectives, interests, principles, and ethics or the active effort to understand others' different perspectives and interests. While these values do not need to be identical across the three sectors, compatibility between them and mutual understanding of the differences in values is needed for successful collaborative engagement (Ansell and Gash [2007](#)).

The three components of structural dimensions, decision-making processes, and interpersonal understanding represent the collaborative dynamics of the system. These three must work together—interactively and iteratively—across the FEW nexus sectors for successful collaborative governance to occur. They inherently operate in a cyclical fashion with a system of feedbacks, whereby each can influence the others. The system also includes external influences and the influence of prior history. Prior history, or historical instances of conflict or cooperation, underlies the collaborative engagement, as previous existence of animosity or of cooperation between sectors can impact collaboration (Ansell and Gash [2007](#)). External influences, components outside of the examined FEW nexus system itself such as economic conditions or climate impacts, can also influence the collaborative governance process.

Indicator Set

The three key components of the conceptual framework include eleven concepts. Each of these concepts contain indicators, which together make up the indicator set to assess the components of the framework. For each of the identified indicators, the accompanying measurement approach, data type, and example from the literature are considered. An overview of the concepts in each of the three framework components is provided in [Table 1](#), with details of these concepts and the indicators for assessment of collaborative FEW nexus governance provided in [Table 2](#).

Case Applications

Africa. These two cases were selected as they provide unique instances of urban water stress in cities with strong interconnections between food, energy, and water resources. To do this, we used several data sources, such as interviews and secondary data, and analysis methods, including qualitative coding and social network analysis. Interviews were conducted with relevant stakeholders, including policymakers, resource users, nonprofit organizations, and local government departments across the food, energy, and water sectors and with related sectors including environmental actors and government officials. Secondary data included news articles, government documents, and peer reviewed literature. These data were analyzed using qualitative coding for key constructs of collaborative governance. A social network analysis was also conducted for the Phoenix case site (Jones and White 2021). These data were then used to conduct a preliminary assessment of the level of collaborative governance within each case. The qualitative designation of low, moderate, or high support of a concept for collaborative FEW nexus governance is based on values for the indicators within each concept and expert interpretation of those values in the context of the case, as has been done in previous study (e.g., Schneider et al. 2015). As this is an initial application of the framework to illustrate how it can be applied, for some concepts, there was not sufficient data collected for assessment.

Phoenix, Arizona, USA

The Phoenix area contains about 5 million residents and is one of the fastest growing metropolitan regions in the nation (U.S. Census Bureau 2020). It has a semi-arid climate with approximately 9 inches of rainfall each year. Previous research has documented strong interlinkages in the physical resource flows between the interconnected FEW nexus sectors (White et al. 2017; Guan et al. 2020). As a desert city, water is central in the management of food and energy resources (White et al. 2017). Agricultural demand accounted for approximately 30% of water used within the urban area in 2017, despite the rapid pace of urbanization (Arizona Department of Water Resources 2020). Energy is crucial for water procurement, distribution, and treatment. For example, energy is needed to pump water through the Central Arizona Project (CAP) canal, which brings water from the Colorado River to deliver it to central and southern Arizona and is the single largest user of electricity in the state (Bartos and Chester

consequences and increase resource security.

Structural Dimensions

The structural dimensions of the FEW nexus governance system in Phoenix are moderately supportive of collaborative governance. First, *institutional support* provides a moderate reinforcement for collaborative governance, as the three nexus sectors have governance structures that operate at different levels. Energy governance is highly centralized around a few sub-regional actors, including utility companies and the Arizona Corporation Commission. Agriculture and food governance is generally decentralized, with most decisions made at the farm level, although some collaborative organizations such as irrigation districts, agricultural cooperatives, and lobbying associations influence agricultural decision-making (Eakin et al. 2016). Governance of water resources consists of numerous actors from various levels and scales to manage the supply and demand of water resources (Larson, Wiek, and Withycombe Keeler 2013). However, with some cross-sector institutions (e.g., irrigation districts) and formal contracts across sectors and between boundary organizations, there is some potential for increased *institutional support* of collaborative governance. Second, the concept *actor inclusivity* provides a high level of support for structural alignment of FEW nexus governance. A social network analysis of the region reveals the large number of actors across all three FEW nexus sectors that are included within the collaborative governance network (Jones and White 2021). Third, the concept *intentional leadership* provides a moderate level of support. In semi-structured interviews with FEW nexus stakeholders, water actors emphasized their desire to initiate collaborations across all three sectors, however energy and food actors expressed that they often felt excluded from water decision-making (Jones and White 2022). This shows mixed perspectives on leadership; the water sector sees themselves as moving engagements forward, but the food and energy sectors see them as failing to include others in collaborative decision-making. Finally, the concept *shared resources* provides minimal support for structural dimensions. Interviewees discussed the limited personnel resources and insufficient time to intentionally engage in collaboration across sectors (Jones and White 2022). This suggests a low level of resource sharing for collaborative governance success.

The decision-making processes of the FEW nexus governance system in Phoenix are strongly supportive of collaborative governance. First, the concept *shared goals* strongly supports decision-making processes. Interviewees noted that having a shared objective when working together motivated them to engage in collaboration, especially if it could lead toward beneficial outcomes that no single organization or sector could achieve on its own (Jones and White 2022). Second, the concept *power balance* also provides a strong level of support. A social network analysis shows a moderately low level of network centralization, which suggests a distributed balance of power in collaboration (Jones and White 2021). However, the same social network analysis shows a low density among the actors in the network, which suggests limited *open communication* among actors (Jones and White 2021).

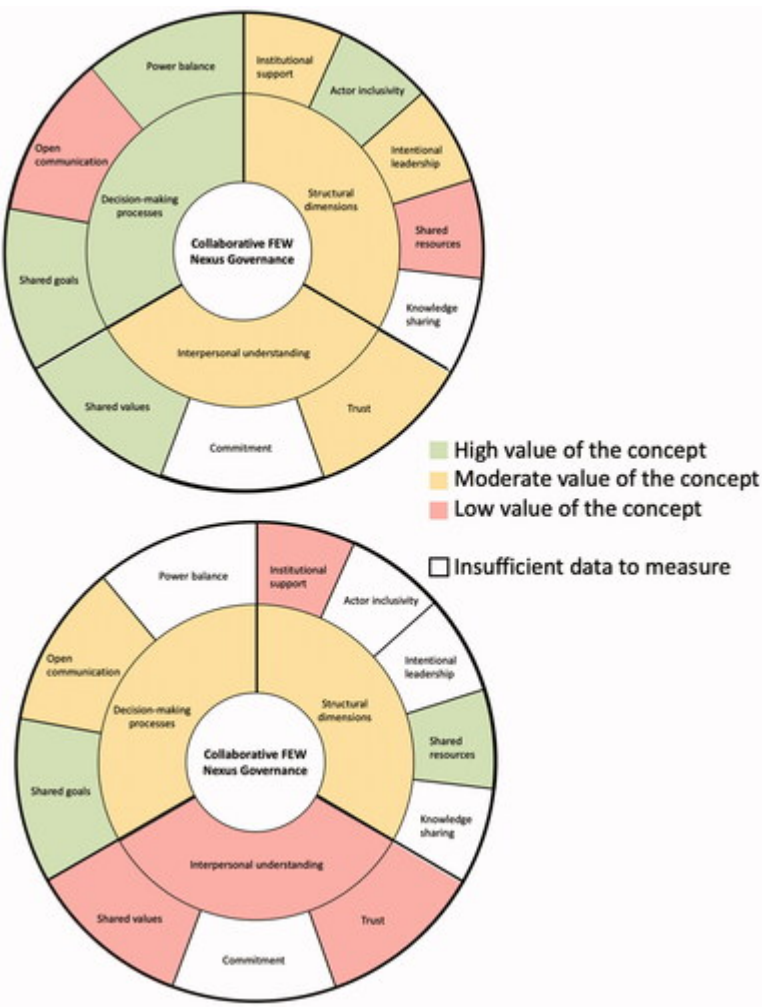
Interpersonal Understanding

Interpersonal understanding within the FEW nexus governance system in Phoenix is moderately supportive of collaborative governance. First, the concept *trust* moderately supports interpersonal understanding among FEW nexus sectors. Through semi-structured interviews, trust was identified as a key component for successful collaboration, though many actors noted a lack of trust in previous engagements that prevented prior success (Jones and White 2022). This suggests that actors may be willing to work to build trust across sectors, but that trust may not be present already. Second, the concept of *shared values* is highly supportive of interpersonal understanding. Many interviewees noted the importance of having shared values, such as open-mindedness and respect, with potential collaborative partners (Jones and White 2022). Thus, a focus on building shared respect and understanding across organizations may be an avenue to improve shared values across the organizations for increased collaboration.

In sum, in the Phoenix case there is a moderate-to-high level of collaborative FEW nexus governance and promise for future collaboration (Figure 2). Collaborative FEW nexus governance in Phoenix is challenged by limited resource sharing and limited communication across sectors. Additionally, with a prior history of conflict between some stakeholders, such as historical tensions between Indigenous peoples and Anglo water-rights holders, collaborative engagement may be further hindered. However, strong attempts to overcome power

and increased trust, full collaborative FEW nexus governance may be possible.

Figure 2. Case assessment wheels for Phoenix (top) and Cape Town (bottom), inspired by Schneider et al. (2015). See online color version for full interpretation.



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Cape Town, South Africa

Approximately 4 million people live in the Cape Town metropolitan area, which is characterized by a Mediterranean climate (Sousa et al. 2018). Interlinkages within the FEW nexus were highlighted through the impacts of the 2018 water crisis, where a three-year drought put major strains on the city’s water supply. The surrounding agricultural regions are key for the provision of food throughout the country and include world-renowned wine regions. Cuts to agricultural

energy-intensive water augmentation approaches, specifically desalination and groundwater pumping. This could strain the city's electrical grid, which already faces capacity issues; the city faced an energy crisis in 2008 (Jaglin [2014](#)) and still has occasional load-shedding. Thus, plans to increase water capacity in the city must consider the potential influence on energy resources for security across both sectors. While the crisis was averted with heavy rains and high urban water conservation, droughts are expected to become more common because of climate change (Pascale et al. [2020](#)) and impacts on the interconnected FEW nexus system are likely to persist. Finally, there are strong inequalities in access to food, energy, and water resources in Cape Town (Ding et al. [2021](#); Enqvist and Ziervogel [2019](#)); we acknowledge the importance of consideration of the complexities of environmental justice within the FEW nexus and argue for future research to examine these complexities.

Structural Dimensions

The structural dimensions of the FEW nexus governance system in Cape Town are moderately supportive of collaborative governance. The three nexus sectors have *institutional support* structures that operate in different ways, and there are limited efforts to overcome these institutional differences. Governance of the agriculture sector is highly decentralized, with most decisions managed at the local level either by individual farms or through local Water User Associations (Termeer et al. [2018](#)). Energy governance, in contrast, is highly centralized at the national level, where a single utility company, Eskom, provides 95% of the country's electricity (Inguscio [2017](#)) and the national government controls regulation and tariff-setting (Kelly and Geyer [2018](#)). Water governance is multi-leveled with much governance occurring at the regional and basin levels, though some power is held at the national level and by municipalities (Beck et al. [2016](#)). These institutional mismatches are compounded by a prior history of political challenges in the country that exacerbate natural resource management, such as the reconstruction post-Apartheid and the tension between the minority party (that currently rules the Western Cape provincial government) and the majority party (that currently rules the national government). A media analysis of news articles surrounding the Cape Town water crisis also showed a high amount of blame for the water crisis placed on government and

different organizations and sectors to address water crisis challenges, suggesting an opportunity for bottom-up efforts of collaborative resource governance.

Decision-Making Processes

The decision-making processes of the FEW nexus governance system in Cape Town show a moderate-to-high level of support of collaborative governance in the response to the 2018 water crisis. First, the concept *shared goals* strongly supports collaborative FEW nexus decision-making. During the water crisis, the goal to avert the crisis and restore water security was a fundamental shared goal among food, energy, and water actors, as noted through various secondary data sources such as media and government documents. Second, the concept *open communication* moderately supports collaborative decision-making. Based on a media analysis, communication appears to exist between different governance levels and between different FEW nexus sectors. However, media also noted that there could have been increased communication in responding to the water crisis.

Interpersonal Understanding

Interpersonal understanding within the FEW nexus governance system in Cape Town is not supportive of collaborative governance. First, the concept *shared values* does not indicate shared perspectives across the three nexus sectors. In a media analysis, instances of shared values were limited. This finding may suggest that the food, energy, and water organizations combating the water crisis may not have similar foundational values, though further investigation through primary data collection is needed. Second, the concept *trust* was not apparent among the FEW nexus governance sectors. Media analysis revealed a strong distrust of elected officials, the government, and resource management departments—trust was only discussed to express distrust of actors.

In the Cape Town metropolitan area, there appears to be moderate-to-low collaborative governance within the FEW nexus ([Figure 2](#)). With structural mismatches between the three sectors, distrust of resource managers and political leaders, limited shared values, a history of conflict with government, and strong inequalities in resource access, the metropolitan area

resilient to future drought shocks and stressors, along with coordination in the decision-making across sectors involved in the water crisis, provides an opportunity for stakeholders to work through these and future challenges, engage in collaboration, and strive toward cross-sector governance for mutual benefit.

Discussion

The framework presented here contributes to the literature by clearly delineating the conceptual components and associated indicators for a comprehensive FEW nexus governance assessment at the urban scale. This assessment provides an avenue to evaluate collaboration in practice, which can be used to: explore the components of FEW nexus governance to identify strengths and weaknesses, monitor FEW nexus governance over time or across implemented interventions, understand how the institutional and governance landscapes change, and validate or challenge the claim that collaborative governance leads to increased resource security and improved management outcomes. Regarding the latter, FEW nexus research has not yet provided conclusive empirical findings about the relationship and correlation between collaborative FEW nexus governance configurations and sustainability outcomes. While FEW nexus governance claims to lead toward positive outcomes (Finley and Seiber [2014](#); Leck et al. [2015](#)), scholars have critiqued the ability of collaborative governance to improve environmental outcomes (Koontz and Thomas [2006](#)). Using this assessment framework can provide a mechanism to assess the governance structure and process to correlate it with sustainability outcomes.

In analyzing the cases of Phoenix and Cape Town, the preliminary application of this framework provides implications for urban FEW nexus governance generally. We identify limited trust between stakeholders across sectors, ineffective communication channels, and mismatched institutional support as potential barriers, which may be present across other cities as well. Institutional support, specifically, may stem from power asymmetries between the sectors, rigid sectoral regulations and planning approaches, and differences in decision-making processes

decision-making, which could hinder the involvement of energy and food stakeholders due to the power asymmetries (Jones and White [2022](#)). Our analysis here also reveals that establishing shared goals between the three sectors can be a catalyst for implementation of collaborative FEW nexus governance, supporting previous findings that have noted the need for convergent policy goals for governance of integrated systems (Vogeler et al. [2019](#)). For example, in Cape Town, stakeholders across the three sectors shared the goal of ending the water crisis, overcoming some previous barriers to collaboration (Ziervogel [2019](#)). Establishing shared goals between sectors, while also actively addressing power asymmetries, building trust, and managing institutional mismatches could foster greater collaborative FEW nexus governance between the sectors. While this framework provides a useful approach to understand and assess FEW nexus governance in practice, future implementation that integrates it with analysis of agency behavior may provide opportunities to further bridge the science-policy divide and to simulate potential reconfigurations of governance through agent-based modeling approaches (Kurian and Kojima [2021](#)). Future implementation could also integrate environmental justice into this assessment framework to consider power and justice concerns more explicitly.

Conclusion

With the strong interrelationships within the food-energy-water nexus, collaborative governance across the three resource sectors provides opportunities to reduce unintended consequences in decision-making and increase resource security. Effective implementation of collaborative FEW nexus governance can be enhanced by the assessment of existing FEW nexus systems. Assessment is essential in understanding the strengths and weaknesses of the integrated governance system and to assess and improve governance approaches. However, there are currently few methods to assess FEW nexus governance. The conceptual framework and assessment indicator set presented here provide an opportunity to address this research gap, as they consider the interplay between governance structural dimensions, decision-making processes, and interpersonal understanding to achieve collaborative governance of the FEW nexus. The preliminary application of this indicator set, in the case cities of Phoenix and Cape

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Additional information

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