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Tending to Critical Gaps in the Water-Energy-Food Nexus for Sustainability Management: Insights from the Rural Industrialized Nexus of Kern County, California

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Tending to Critical Gaps in the Water-Energy-Food Nexus for Sustainability Management: Insights from the Rural Industrialized Nexus of Kern County, California

A dissertation submitted in partial satisfaction of the requirements for the degree
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in

Management of Complex Systems

by

Deseret M. Weeks

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2024

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Abstract of the Dissertation

Tending to Critical Gaps in the Water-Energy-Food Nexus for Sustainability Management: Insights from the Rural Industrialized Nexus of Kern County, California

By

Deseret M. Weeks

Doctor of Philosophy in Management of Complex Systems

University of California, Merced

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Dr. Jeffrey Jenkins, Chair

Managing the water-energy-food (WEF) nexus for sustainability is one of the grand challenges of the 21st century, representing a critical space for social change. In recognition of the inadequacy of conventional approaches to WEF nexus research and management and to decolonize the sustainability movement, this dissertation contributes a variety of radical and social science approaches to nexus research. As a complex socio-environmental system, the dissertation broadly asks how the broader political-economic system influences the WEF nexus. A mixed methods case study of the rural industrialized WEF nexus of Kern County, CA, was conducted. The case study moves beyond technical explanations and solutions typical in WEF nexus research and management by conceptualizing local socio-environmental processes as embedded within and operating according to broader patterns and relations of domination stemming from the global economic system of capitalism. Key contributions of this dissertation are its focus on water pollution stemming from nexus processes, critical theoretical explanations for the behavior of the nexus as a complex socio-environmental system, and social dimensions of the WEF nexus. Each chapter of this dissertation, following chapter one introduction, contributes answers to the broad research question, fills gaps in WEF nexus research, and provides complimentary insights relevant to the WEF nexus for sustainability management.

Chapter two of the dissertation joins the limits to growth to Marx's metabolic rift theory as the theoretical frame to investigate and explain water pollution stemming from the rural nexus industries of fossil fuel development and industrial agriculture using nexus industry-related chemicals, spatial analysis, and CA's public health goal safety thresholds. The results showed that the limits to nexus industry growth have been exceeded and that nexus industry pollution exposure risk increases with proximity to nexus industries. The limits to growth explained that the rural industrialized nexus of Kern County is producing pollution exposure risk stemming from three main complex systemic functions within the demands for infinite industrial expansion and the ecological limits for ecosystem renewal. On the other hand, Marx's metabolic rift theory provided qualitative explanations for the spatial analysis that showed pollution exposure risk increased with proximity to nexus industry sources of pollution, thus symbolizing the metabolic

rift as a water quality crisis of capitalism and a need for social change. The pollution exposure risk zones provided a region to engage with the local community for investigating local social dimensions in the nexus in subsequent research.

Chapter three evaluates the two interdependent dimensions of sense of place, place attachment and place meaning, as drivers of perceptions of the impacts of industrial agriculture and fossil fuel development in the pollution exposure risk zones delineated in chapter two. Methods of analysis include factor analysis, bi-variate correlation, comparison of the perceptions of impacts between the two industries, and theoretical explanations for the results in the discussion section. Two key findings of chapter three are that nexus industries have shaped place meaning and that, while place attachment appears to be weak due to environmental alienation, it is rooted in nexus industries, particularly the fossil fuel industry. The chapter discusses the implications of the results for sustainability management and concludes with strategies to build support for sustainability policy. The strategies include directing funds from Kern County's renewable energy industry to local sectors of society, implementing regenerative agriculture, cooperative management, and nurturing place meaning as aligned with nature's restorative quality.

Chapter four includes a spatial analysis of tap water pollution and explores the social dimensions of experience and rationality in the rural industrialized WEF nexus using critical thematic analysis and a green criminology lens. The chapter contributes a radical approach to WEF nexus research and ultimately suggests a redefined version of the UN's sustainable development goal 6 – clean water and sanitation. The chapter provided evidence that industrial agriculture and fossil fuel development are producing harm (green crime) in the form of ecological disorganization, environmental injustice victimization, and unequal ecological exchange. The chapter also problematizes economic rationale in sustainable "development" and as a local social dimension in the WEF nexus, with the nexus representing the treadmill of production. Evidence from the case study provides the basis for a critique of the sustainable development goals based on the triple bottom line of people, planet, and profit as a neoliberal articulation of sustainable development. A key takeaway from chapter four is that environmental problems in the WEF nexus and sustainability cannot be reduced to capitalism alone because the logic, or rationale, of geopolitics also drives the problems. Redefining the sustainable development goals to attain sustainability must also take on the enormous task of transforming the logic and rationalization of individuals. Additional key takeaways from this chapter include the need for scientific thresholds for water quality in the sustainable development goals and a list of target chemicals for water quality monitoring related to rural WEF nexus industries. Further green crime case studies of the rural WEF nexus are also advised to build momentum for support for social change.

Chapter 1 Introduction

Water is central to the function of life and societal systems and is thus a determinant of sustainability – "the ability of systems to persist, adapt, transform or transition in the face of constantly changing conditions" (Falkenmark and Rockström, 2004; Williams et al., 2017). In biological organisms, for example, while, as a fluid, water facilitates the movement of materials as required in metabolic processes, it is also a universal solvent that provides for the dilution and elimination of harmful substances and waste materials (Bracht, 2004; Young and Haveman, 1985; Ali et al., 2019). As the "bloodstream of the biosphere," water delivers nutrients, nourishing ecosystems and individuals living in those systems (Ripl, 2003; Falkenmark and Rockström, 2004). Parallel to the roles that water plays in supporting Earth's ecosystems, water is at the center of the function of human society, industrial development, and the economy. Indeed, while social and economic systemic activities (urbanization, industrial production, energy development) and intensity rely on the availability of water, those activities rely on water in quantity and quality just as biological organisms do for metabolic processes and dilution and elimination of harmful substances and waste materials (Bracht, 2004; Falkenmark and Rockström, 2004; Rockström et al., 2014; Young and Haveman, 1985; Ali et al., 2019). The central roles of water represent its significance for optimal systemic function and resilience, which is the capacity to maintain systemic functions, adapt, and recover from disturbance (Walker et al., 2004; Falkenmark et al., 2019; Holling, 1973; Boltz et al., 2019). Because it is a "master variable," water is at the center of concerns for sustainability management (Boltz et al., 2019; Gleick, 1998; Wiek and Larson, 2012).

As a source of tensions, conflicts, and inequity, water scarcity is a central concern for sustainability across the social and environmental sciences (Sultana, 2018; Jury and Vaux, Jr., 2005; Anderson et al., 2019). While water covers about 70% Earth's surface, just 2.5% of that water is freshwater, and of that freshwater, less than 1% is accessible for human use (Mishra, 2023). Whereas industrial agriculture alone consumes about 85% of the global freshwater supplies, global food production is expected to double in the next 50 years (Jury and Vaux Jr., 2007). Meanwhile, climate change, privatization, urban expansion, and industrial extraction and pollution are exacerbating issues of water quantity and quality (Falkenmark and Rockström, 2004; Mishra, 2023; Shiva, 2002; United Nations, 2023; Anderson et al., 2019; Arnell, 1999). The stressors of human society on global water supplies have led to the planetary boundary of *freshwater change* for a safe operating space for humanity to be crossed as per the 2023 update, indicating that there is a water crisis that parallels in magnitude that of the climate crisis (Richardson et al., 2023; Bunsen et al., 2021).

While sustainability scientists increasingly emphasize the need for social science, complex systems, and interdisciplinary approaches, a problematic barrier to the management of water throughout the history of society has been the tendency for humans to view water management as mainly a technical issue (Falkenmark and Rockström, 2004; Rogers et al., 2012; Gasparatos et al., 2008). As an example, while population growth continues to define the "fundamental dilemma" of water being scarcity, pure positivist approaches of the natural sciences continue to dominate research and management strategies (Falkenmark and Rockström, 2004; Wessenlink et al., 2017; Albrecht et al., 2018). Problems with pure positivist approaches to sustainability management include systemic compartmentalization, reductionism, and the use of linear methods of analysis that do not match real-world complexity (Anderson, 1999; Meadows, 2008; Williams et al., 2017; Gasparatos et al., 2008). Moreover, managing crises of the Anthropocene requires social theory and social science methods considering the role of human values, perceptions, knowledge, and the power of collective action in policy decision-making processes (Palsson et al., 2013; Holling, 1973; Berkes, 2017). Some highlight the failure of sustainability science networks to confront qualitative questions of meaning, value, social norms, and power relations that drive environmental problems, which has led to narratives dominated by natural sciences as opposed to the needed narrative of social change (Lövbrand et al., 2015; Jerneck et al., 2011; Lahsen and Turnhout, 2021). Similarly, others explain that the roots of sustainability science being economic theory provide a utilitarian approach to management that enables a business-as-usual path of development that provides a means to an end but will not solve problems of social and environmental injustice, such as those associated with the global water crisis (Gasparatos et al., 2008; Sultana, 2018; Sakalasooriya, 2021; Lahsen and Turnhout, 2021; Pahl-Wostl et al., 2011).

To confront global scale crises of the Anthropocene, such as the water crisis, sustainability science must change. Chopra and Luisi (2016) refer to Khun's (2012) scientific revolutions to explain that science is experiencing a paradigm shift in which, due to crises faced today, the community of science is increasingly seeing the world as an ecological whole as opposed to a machine. This shift to systems thinking in Western science is exemplified by the growth of branches of complex systems science since the 1950s stemming from concerns for sustainability (Boulding, 1956; 1966; Meadows et al., 1972; Holling, 1973; Schnaiberg, 1980; Odum and Odum, 1981; Berkes et al., 1998; Wallerstein, 2004; Armitage et al., 2008; Meadows, 2008; Ostrom, 2009; Folke et al., 2011). Also an aspect of this shift has been a call for interdisciplinarity among sustainability and complex systems management scientific communities (Young et al., 2006; Stock and Burton, 2011; Armitage et al., 2007). A (re)structuring of the science community is represented by the materialization of socio-environmental systems (SESs) (AKA socio-ecological systems) science and management. SESs research and management entails modeling interconnected social and environmental systems as complex adaptive systems to investigate, predict, and manage sustainability problems (Elsawah et al., 2020; Folke et al., 2016). SESs science has also encouraged the inclusion of Indigenous knowledge and grassroots organizations in science and decision-making as well as the use of mixed-methods approaches, all of which have fostered interdisciplinarity and identification of pathways for sustainability (Armitage et al., 2007; Musters et al., 1998; Turner II et al., 2016).

1.1 The need for "radical" approaches to science

Considering this paradigm shift and that water is at the center of socio-environmental processes, why is water management still being viewed as mainly a technical issue (Rockström et al., 2014)? In recognizing that complex systems science alone is insufficient, "radical" changes in sustainability science and management are being called for (McPherson et al., 2021; Ergene et al., 2020; Pirgmaier and Steinberger, 2019). "Radical," referring to the advocation of extreme changes in political views, policies, and practices, or to "remove the root of a disease," represents an aspect of the current scientific revolution aligned with critical theory (Adler et al., 2007; Merriam-Webster, 2024). Built by the work of several generations of social theorists and philosophers, critical theory is a "family of theories" that aim to critique societal structures of power and transform society by integrating normative perspectives with empirical and theoretically-informed analyses of social contradictions, conflicts, and inequity (Kincheloe and McLaren, 2011; Corradetti, 2020). Marxian political economy is at the heart of radical approaches to sustainability science as exemplified in critical geography, political ecology, and environmental sociology, all of which take on case studies of environmental destruction and increasing social inequity stemming from the contradictions of capitalism and political economic power (Peet, 1977; Peet and Thrift, 1989; Castree, 1999; Foster, 1999; Gould et al., 2008, Schnaiberg, 1980). While historical realism, the view that reality is shaped by economic, cultural, political, and social values over time, is the ontological position of critical theory, its epistemology, subjectivism, is based on "real world phenomena," hinged on "societal ideology" (Scotland, 2012). Within this epistemology, societal power relations influence knowledge and knowledge can be socially constructed (Scotland, 2012). Critical (radical) research thus views local social processes as embedded within, and operating according to, broader patterns and relations of domination, mainly as related to the global economic system of capitalism (Adler et al., 2007; Harvey, 1990; Peet and Thrift, 1989). Because of this, critical research moves beyond technical methods and explanations. For example, methodologies in critical theory bridge the qualitative and quantitative divide through critical analysis that incorporates empirical methods (qualitative and quantitative) of analyses backed with social science theories that provide for critique of the political economic origins of systemic inequity and environmental degradation to facilitate change (Antonio, 1981; Foster, 1999; Peet and Thrift, 1989). Thus, critical theory supplies the needed theoretical frame and methods for sustainability science research and management to confront qualitative questions of meaning, value, social norms, and power relations that drive environmental problems.

Radical approaches to science also provide critical reflexivity, which is needed considering the roots and goals of sustainable development that guide sustainability science. For example, as a redirection of the environmental sustainability movement of the 1970s, the United Nations-sponsored World Commission on Environment and Development's (WCED) (1987) publication of *Our Common Future* (AKA The Brundtland Report) called for a recalibration of institutional mechanisms to promote economic development to guarantee "the security, well-being, and survival of the planet" (WCED, 1987; Sneddon et al., 2006). Critiques of the report warn that goals of economic development are contradictory to environmental sustainability and that the concept of sustainability has been coopted to enable industrial expansion and continued exploitation of underdeveloped regions of the world (Lélé, 1991; Doyle, 2010; Worster, 1993; Sachs, 1991; Redclift, 2005). Within conventional sustainability and SESs science, the goals of the Brundtland Report have been embraced or accepted as a compromise in the spirit of cooperative management or bipartisanship (Sneddon et al., 2006; Folke et al., 2016; Lambin and Mayfroidt, 2010; Wiegleb and Bruns, 2018; Cortner and Moote, 1994). This has resulted in economic objectives (resource security) and methods (ecological economics) dominating sustainability research and management strategies due to the 'triple bottom line' goal of development being the economy, environment, and society, also referred to as the three Ps – people, planet, and profit (Murphy, 2012; Lacitignola et al., 2007; Giddings et al., 2002; Dempsey et al., 2011; Redclift, 2005). Peet (1977) explains that "it is the function of conventional, established science to serve the established, conventional social system and, in fact, to enable it to survive." To avoid the self-reproduction of the social system dynamics driving environmental destruction and social inequity, sustainability science must be willing to self-critique and reject economic growth imperatives as part of the sustainability movement – to reject "development." Critical reflexivity as an inherent aspect of radical approaches to science provides a mechanism to reject the coopting of the sustainability movement by the global economic development movement (Doyle, 2010; Peet, 1977).

1.2 The water-energy-food nexus

A commonly used SESs model for the conceptualization and analysis of water as a master variable for sustainability is the water-energy-food (WEF) nexus. The emergence of the WEF nexus, or nexus thinking, was fueled "by fears linked to the 2007-2008 food and energy price shock" (Allouche et al., 2015). In response to these concerns, the World Economic Forum published a paper promoting the WEF nexus in 2011, *Water Security: The Water-Food-Energy-Climate Nexus*. Chapters of the paper were authored by individuals working for corporate members of the World Economic Forum, such as Nestle, PepsiCo, Coca-Cola, Dow Chemical Company, and the World Trade Organization, among others (WEF, 2011). The theme was water security and the development of technology to enhance water security for global corporate industries to ensure sustainable economic growth (WEF, 2011). The paper highlighted a projection that human water demand will surpass global supplies by 40% by 2030 (WEF, 2011). Accordingly, considering population growth, finite water supplies, and the influence of climate change, water was characterized as a "constraint" for urban and industrial expansion, with bankers and corporate executives citing water as "the only natural limit for economic growth" (WEF, 2011).

At a corresponding event, the WEF nexus was also promoted at the Bonn 2011 Conference: The Water, Energy and Food Security Nexus – Solutions for the Green Economy (IISD, 2024; Lazarus, 2010; Granit and Lindström, 2009). The conference, purportedly "high-level" and by invitation only, was organized by "the German Federal Government in collaboration with the World Economic Forum, the World Wildlife Fund, and the International Food Policy Research Institute" and sought to "contribute to the run-up to" the 2012 United Nations Conference on Sustainable Development – Rio+20 (IISD, 2024). The background paper for the Bonn 2011 conference, *Understanding the Nexus*, outlined why a nexus approach is needed for sustainability, guiding principles, and opportunities to improve water, energy, and food security (Hoff, 2011). While, building from concepts of SESs research, the paper highlighted that the nexus approach facilitated resource sector integration at multiple scales and interdisciplinary collaboration, primary objectives using the nexus approach were to accelerate development and extend industrial agriculture into underdeveloped regions to address food insecurity (Hoff, 2011). These objectives, facilitated by nexus approaches, would boost economic growth to address poverty (Hoff, 2011). While industrial development and globalization were aspirations, greening the economy would support sustainable development based on technological innovations and payments for ecosystem services such as carbon trading, water markets, and "tradeable rights" (Hoff, 2011). The paper, and the concept of the WEF nexus, provided key policy objectives for the sustainable development goals (SDGs) that materialized from the Rio+20 international sustainability development agreement – the Millennium Development Goals (Zukang, 2012). Because the agreement was based on the three pillars of development (economic development, social development, and environmental protection), or the triple bottom line, there was immediate recognition that the environment protection pillar would need greater attention and strengthening (Zukang, 2012; Sachs, 2012; Hoff, 2011).

While Allouche and colleagues (2015; 2019) identify managing the WEF nexus as "one of the grand challenges of the 21st century," they caution that the concept of the nexus is immature. With nexus framings being based on a neoliberal water security agenda to attain food and energy security, environmental justice and structural inequality questions get placed on a backburner or omitted entirely (Allouche et al., 2015). This is largely due to the economic rationale framing water quantity as the primary concern for WEF nexus research and management which has resulted in positivist approaches dominating conventional research (Simpson and Jewitt, 2019; Bruns et al., 2022; Allouche et al., 2015). Also problematic within conventional nexus framings is the encouragement of "commodification of resources, downplaying of environmental externalities," and exclusion of local experiences and social constructs important for sustainability management (Allouche et al., 2015; 2019; Bruns et al., 2022). While there has been progress in bringing local social dynamics into nexus research, for example, local livelihoods, local environmental degradation stemming from nexus processes at the intersection of local social dimensions remains a research gap (Biggs et al., 2015; Liu et al., 2018; Albrecht et al., 2018; Biggs et al., 2015; Allouche et al., 2019).

In order to decolonize sustainability within WEF nexus framings and attend to issues of social inequity and environmental degradation, radical social science approaches are needed (Bruns et al., 2022; Allouche et al., 2019; Wiegleb and Bruns, 2018). Promoting a political ecology approach to framing nexus research, Bruns and colleagues (2022) detail key differences between conventional SESs framings and critical framings. They draw from Wessenlink and colleagues' (2017) comparison between the conventional socio-hydrology approach and the critically oriented hydrosocial approach. The key aspects of each are shown in Table 1-1 and reflect how radical approaches differ from conventional approaches in WEF nexus research. For example, the theoretical perspective of conventional methods to WEF nexus research ranges from positivism to post-positivism. Within this paradigm, the epistemology of objectivism separates the object from the subject effectively preventing the needed connection between society and the environment for sustainability management (Moon and Blackman, 2014; Forsyth, 2004). On the other hand, the epistemology of radical approaches is that of constructivism and subjectivism with an ontology ranging from critical realism to relativism (Moon and Blackman, 2014; Bruns et al., 2022; Wessenlink et al., 2017). Thus, meaning is created from interplay between the subject and object (human and environmental systems) and meaning exists within the subject as a whole (Moon and Blackman, 2014). Further, Moon and Blackman (2014) explain that social science approaches to research are needed for environmental conservation science because positivist approaches alone do not provide an application for emancipation or liberation from social structures of power. Critical theory and social constructivism and interpretivism in social science approaches provide the ability to critique systemic structures of inequality and understand meaning-making processes and interpretations of reality (Moon and Blackman, 2014; Wiegleb and Bruns, 2018; Allouche et al., 2019; Haggerty et al., 2019). Decisions about policies that affect sustainability management can be improved by incorporating local perceptions and values within the context of political economic influences, the understanding of which comes largely from social and radical science approaches (Mulvaney et al., 2020; Craik, 1973; Adger, 2006; Dietz et al., 2005).

Table 1-1: Table provides a comparison of conventional versus radical approaches to water-energy-food nexus research. Information in the table draws heavily from Moon and Blackman, 2014; Bruns et al., 2022, and Wessenlink et al., 2017, and lesser so from de Vos et al., 2019 and Albrecht et al., 2018.

Research approach characteristics	**Conventional approach** (e.g. Complex SESs; WEF nexus)	**Radical approach** (e.g. critical geography, political ecology, environmental sociology)
Paradigm	Positivist; post-positivist	Constructivist; Critical theory

Ontology	Realism; (Structural)Realism; Anthropocentric, coupled human-natural systems	Critical realism; Relativism; Holistic; systemic parts constitute a whole and cannot be separated
Epistemology	Objectivism; Object is independent of the subject	Constructionism; Subjectivism; inter-subjective
Main methods	Quantitative modeling, linear statistics; ecological economics; GIS; adaptive co-management	Historical materialist analysis, mixed-methods, qualitative methods, environmental justice, GIS
Axiology	Post-positivist; Researchers should be neutral	Critical and interpretivist; researchers cannot and should not be neutral
Typical scale of research	Large; landscape scale	Uneven development at large scales; urban-rural differences; local; individual

1.3 Dissertation aims, objectives, and chapters overview

This dissertation aims to explain the function of the WEF nexus as a complex SES within the context of the global economic system of capitalism with an eye on water quality and local social dimensions important for sustainability management. Understanding the function of systems provides the basis for initiating change (Odum, 1969; Harvey, 2014). This dissertation contributes a radical approach to conceptualization and research to explain SES function and to stimulate transformative change in the WEF nexus as an important space in sustainability science and for sustainability management. This research aims to decolonize the WEF nexus and is thus oriented towards social and environmental challenges as opposed to economic growth objectives (Weber and Rohracher, 2012; Wilson et al., 2019; Allouche et al., 2015; 2019). Moving beyond technical explanations and solutions typical in WEF nexus research and management, this research views local socio-environmental processes as embedded within, and operating according to, broader patterns and relations of domination stemming from the global economic system of capitalism (Wilson et al., 2019; Adler et al., 2007; Harvey, 1990; Peet and Thrift, 1989; Allouche et al., 2015; 2019). While the WEF nexus is characterized as the intersections between industrial agriculture, fossil fuel development, and water (Figure 1.1), as a multi-scalar SES, local social dimensions as integral to the nexus and functioning also within the context of the global economic system represents key foci of the research. Accordingly, this dissertation is based on the research question:

As a complex SES, how is the WEF nexus influenced by the broader political economic system of capitalism?

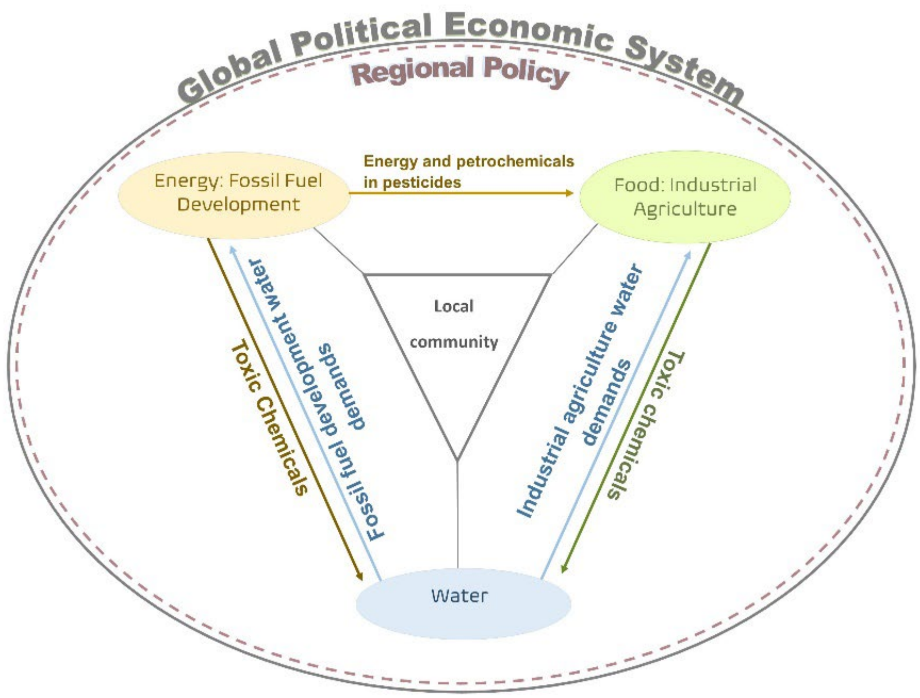

Figure 1.1: The WEF nexus is conceptualized as a complex socio-environmental system. Chemicals used in nexus industries influence local water quality. The nexus is a multi-scalar socio-environmental system functioning within the context of the global economic system. Figure by author, inspired by Lawford, 2019

To answer the general research question, a single embedded case study of a rural industrialized WEF nexus is conducted. While Yin (2018) highlights that the "distinctive need for case studies arises out of the desire to understand complex phenomena" and that case studies are appropriate for tracing operational processes over time, Ravitch and Carl (2016) highlight that case studies are "useful when the researcher seeks to understand an issue or problem using a case as an illustration." Further, case studies provide the ability to investigate mechanisms for, and societal underpinnings of, unsustainability as they provide a method to approach a case within its geographical and historical context (Ravitch and Carl, 2016). This research centralizes on the rural industrialized WEF nexus for key reasons. As representative of the WEF nexus, fossil fuel development and industrial agriculture are rural industries that increasingly occur in the same areas and continue to expand (Measham et al., 2016; Rockström et al., 2014). Meanwhile, the demands for energy and food within the broader market rationale of infinite economic growth and industrial expansion are contradictory to ecological limits of water quality renewal capacity, making the rural WEF nexus an essential focal point for sustainability research (Meadows et al., 1992; Vargas et al., 2023). The case study centers on Kern County, CA which bears the cumulative impacts of intense rural industrial development, with industrial agriculture and fossil fuel development being the dominant industries (London et al., 2021). While the following dissertation chapters explain the case context in greater detail, a key aspect of the case is that rural nexus industries in Kern County are of colonial origins and have deep roots in the socio-environmental system of the County. Thus, considering "development" continues to follow a path towards industrialization, the WEF nexus of Kern County provides an important case study of the outcomes of industrial development and the function of the nexus within the context of the global economic system.

1.3.1 Chapter 2 Overview:

Chapter two of the dissertation "*Tending to sustainability gaps in the rural industrialized water-energy-food nexus: A spatial investigation of pollution exposure risk and insights from the limits to growth and Marx's metabolic rift theory*" sets the stage for research in the final two chapters and has three primary objectives: 1) Provide a radical conceptualization of the WEF nexus. 2) Prioritize water quality in WEF nexus research. 3) Identify areas to engage with local community members to collect data. The first chapter joins the limits to growth with Marx's metabolic rift theory as its theoretical frame to explore water pollution in tap water materializing from nexus industries. The theoretical assumptions of the frame are tested by exploring evidence for the exceedance of the limits to economic growth in the industrialized WEF nexus and to provide theoretical explanations for the function of the nexus within the context of the economic system.

This research acknowledges the important contributions of Meadows and colleagues' (1972) *Limits to Growth* to the development of sustainability science. Based on complex systems science, the models of the limits to growth provide conceptualization and statistical evidence that Earth has finite natural resources and pollution sinks (Meadows et al., 1972; 1992). The models have provided the basis for further research within conventional science based on the understanding that infinite industrial development expansion is contradictory ecosystem renewal, Earth's carrying capacity, and thus sustainability (Ekins, 1993; Rockström et al., 2009; Goodland and Daly, 1996). A key contribution of the limits to growth for sustainability management though is its statistical basis for making the argument that exponential economic growth and related industrial expansion could result in the "overshoot" of ecosystem capacity for renewal and risk of collapse (Meadows et al., 1992). Thus, safety thresholds for environmental pollution are needed for environmental quality monitoring and sustainability management (Rockström et al., 2009; Meadows and Randers, 2004). Like water research and policy and WEF nexus conceptualizations, though, the limits to growth falls short of being able to explain the social and political-economic drivers of environmental degradation and socio-environmental crises (Mehta et al., 2019; Hannigan, 1995; Gould et al., 2008).

Marx's Metabolic Rift Theory provides a radical supplement to the limits to growth as a complex systems science method for understanding the function of socio-environmental systems. The theory explains that capitalism relies on a social structure of inequality whereby exploitation of the working class and the environment provides for the accumulation of wealth by those in power (Lynch et al., 2017). The result in increasing social inequity, uneven geographical development, and socio-environmental crises (Harvey, 2014). Capitalism is crisis-prone because ensuring capital accumulation continues indefinitely, increasingly intensive labor, mechanization, use of chemicals, and environmental exploitation is required (Schnaiberg, 1980; Clark et al., 2022; Lynch et al., 2017). This process produces external costs (negative externalities) such as environmental pollution and related health risks, which are contradictory to sustainability (Foster, 1999; Lynch et al., 2017; Klein, 2007).

While water quantity has been the primary concern in WEF nexus research for sustainability management, water quality and water pollution materializing from nexus processes remain critical research gaps (Albrecht et al., 2018; Zarei et al., 2021; Wang et al., 2021; Liu et al., 2018). Overlooking water quality is problematic for sustainability, considering the environmental and public health risks associated with industrial agriculture and fossil fuel development. For example, water pollution materializing from industrial agricultural inputs of synthetic fertilizers and pesticides into the environment is a global-scale problem for sustainability and a driver for the exceedance of the planetary boundaries (Horrigan et al., 2002; Campbell et al., 2017). Excess nitrogen and phosphorus from industrial agriculture leads to harmful algal blooms and plant overgrowth, oxygen depletion, and dead zones in aquatic ecosystems globally, threatening biodiversity and food security (Zahoor and Mushtaq, 2023; Diaz and Rosenberg, 2008). Nitrogen in public water resources due to agricultural activities and fossil fuel development and use poses serious risks for human health such as blue baby syndrome, cancer, thyroid disease, and neural tube defects (Zahoor and Mushtaq, 2023; Hauptman and Naughton, 2021; Balazs et al., 2011; Ward et al., 2018). Meanwhile, the development and use of fossil fuels and the use of petrochemicals in pesticides are linked to the materialization of harmful organic and inorganic chemicals in local water resources, increasing risk for cancer and many other human health disparities (Wollen et al., 2020; Parvez et al., 2019; States et al., 2013).

Chapter two employs California's public health goal safety thresholds for water quality as the basis for a spatial analysis of pollution exposure risk and to test if the limits to growth in the WEF nexus have been exceeded. Environmental toxicology case studies provided a set of nexus industry chemicals of interest as well as insights into socio-environmental risks posed by the chemicals. Environmental justice mapping methods and water quality data for zip codes throughout Kern County, CA were used to delineate water pollution exposure risk zones to test the theoretical assumptions. Results supported the theoretical assumptions that capitalist industrial development is producing a water quality crisis in the WEF nexus. While most of the nexus industry-related chemicals of focus exceed safety thresholds throughout the valley portion of the county, levels increase with proximity to nexus industry sources of pollution. Individuals in the risk zones are at far greater risk for exposure to the chemicals in tap water. The limits to growth and Marx's metabolic rift theory provide complex systemic function explanations for the geographical concentration of pollution in tap water with proximity to nexus industries in the discussion section as well as directives for sustainability management. The case study concludes with key directions for WEF nexus research to promote sustainability management success. Those research directives were used to formulate the final two chapters of research.

1.3.2 Chapter 3 Overview

Chapter three "*Sense of Place and Perceived Impacts in the Rural Industrialized Nexus: Insights for Sustainability Pathways*" explores the local social dimension of sense of place (SoP) and perceived social, environmental, community, and economic impacts of rural nexus industries. The chapter evaluates the two interdependent dimensions of SoP, place attachment and place meaning, as drivers of perceptions of the impacts of industrial agriculture and fossil fuel development using factor analysis, bi-variate correlation, and comparison of the perceptions of impacts between the two industries (Jacquet and Stedman, 2013). Place attachment, the bond between an individual and a place, and place meaning, the cognitive and descriptive elements of attitudes about a spatial setting, undergird positions on policy and play important roles in perceptions of the environment and the impacts of industry (Brehm et al., 2013; Davenport and Anderson, 2006; Stedman, 2002; Stedman, 2008; Brown et al., 2015; Hernández et al., 2007). These dimensions of SoP can be shaped by a variety of factors including experiences of pollution and the broader political economic system (Harvey, 1993; Cross et al., 2011; Cresswell, 2008). Results of chapter three showed that place meaning and place attachment are drivers of perception of the impacts of nexus industries while also being drivers of concern for changes in the local industry. An important finding of the chapter is that, due to long-term industrialization, nexus industries have shaped place meaning and place attachment and that nexus industries, particularly fossil fuel, are experienced as being an integral part of the local social system providing multi-faceted stability to local livelihoods. The chapter discusses the implications of the results for sustainability management and transitions and demonstrates the relevance of social science approaches in WEF nexus research as relative to sustainability management. The chapter concludes with strategies to build support for sustainability policy including directing funds from Kern County's renewable energy industry to local sectors of society, implementation of regenerative agriculture, cooperative management, and nurturing place meaning as aligned with nature's restorative quality. The strategies suggested will support sustainability management in the nexus by strengthening place attachment, building trust in government, and repairing environmental alienation (Harvey, 1993; 2018; Stedman, 2002; Lokhorst et al., 2014; Hausmann et al., 2015; Quinn et al., 2019; Marshall et al., 2019; Armitage et al., 2007; Chapin and Knapp, 2015).

1.3.3 Chapter 4 Overview

Chapter four "*Exploring Green Crime and Rationalization in the Rural Industrialized Water-Energy-Food Nexus*" addresses the problem of water pollution and explores the social dimensions of experience and rationality in the rural industrialized WEF nexus. Using a green criminology lens, this mixed methods case study contributes a radical approach to WEF nexus research and suggest a redefined version the UNs sustainable development goal 6 – clean water and sanitation (United Nations, 2022; 2023; 2024; Lynch et al., 2017; Blaustine et al., 2018; Allouche et al., 2019). The research uses quantitative water quality data and qualitative survey responses to ascertain if green crime is occurring in the WEF nexus of Kern County and how political-economic structures are shaping socio-environmental experiences and rationalization. Chapter four builds from chapter two. Using California's public health goal safety thresholds for the spatial analysis of nexus industry-related chemicals in tap water, the chapter provides evidence that industrial agriculture and fossil fuel development are producing harms in the form of ecological disorganization, environmental injustice victimization, and unequal ecological exchange (OEHHA, 2024; Balazs et al., 2012; Rabinowitz et al., 2015; Wollen et al., 2020; Mennis and Heckert, 2018; Mennis, 2000; Meng, 2015; Stretesky et al., 2013; Lynch et al., 2013). Critical thematic analysis of qualitative survey responses regarding the impacts of nexus industries produced nine codes, five of which fed into an initial theme of political-economic rationale which fed into a refined theme of the treadmill of production. A final theme of unequal (ecological) exchange provided an unexpected link between the treadmill of production and the third final theme of green crime – ecological disorganization and socio-environmental injustice. The chapter also problematizes economic rationale in sustainable "development" and as a local social dimension in the treadmill of production. Evidence of the case study provides for a critique of the sustainable development goals being based on triple bottom line of people, planet, and profit as a neoliberal articulation of sustainable development. A key takeaway is that environmental problems in the WEF nexus and for sustainability cannot be reduced to capitalism alone because the problems are also driven by the logic, or rationale, of geopolitics (Hooks and Smith, 2004). Redefining the sustainable development goals to truly attain sustainability must also take on the enormous task of transforming the logic and rationalization of individuals. Additional key takeaways from this chapter include the need for scientific thresholds for water quality in the sustainable development goals and a related list of target chemicals for water quality monitoring related to rural WEF nexus industries. Further green crime case studies of the rural WEF nexus are also advised to build momentum for support for social change.

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Chapter 2 Tending to sustainability gaps in the rural industrialized water-energy-food nexus: A spatial investigation of pollution exposure risk and insights from the limits to growth and Marx's metabolic rift theory

Abstract

This this research conceptualizes the WEF nexus as a complex socio-environmental system and joins the limits to growth with Marx's metabolic rift theory as its theoretical frame to bridge the quantitative-qualitative divide and provide needed critical theoretical interrogations. The theoretical assumptions are tested in a pollution exposure risk case study of the rural industrialized WEF nexus of Kern County, California. Buffer analysis was used to delineate nexus industry pollution exposure risk zones and to identify critical areas to conduct further research on social dynamics in the WEF nexus. The zones were validated using California's public health goal safety thresholds for chemicals in tap water and water quality measurements. Results show that, while the limits to growth have been exceeded and there is a water pollution crisis in the rural WEF nexus of Kern County, individuals in the risk zones are at greater risk for exposure and related health impacts. Further research for sustainability management in Kern County's WEF nexus and other rural regions that have undergone intense industrial development include:

(1) Utilization of research and management frameworks that hinge the limits to growth (minus its Malthusianism) to a critical theory such as Marx's metabolic rift theory.
(2) Further case studies to create a database of water pollution in the rural industrialized WEF nexus as an important contribution of data for the planetary boundary of *novel entities*.
(3) Engagement with and management based on sustainability transitions discourses.
(4) Case studies of green crime, environmental injustice, and political-economic power dynamics.

2.1 Introduction

Being central to the function of life and socio-environmental systems, water is a determinant of sustainability, and increasingly, a source of conflict (Falkenmark and Rockström, 2004; Williams et al., 2017; Sultana, 2018; Jury and Vaux, Jr., 2005; Anderson et al., 2019). Due to ever increasing demands for water, it is projected that human water demand will surpass global supplies by 40% by 2030 (WEF, 2011). While industrial agriculture alone consumes about 85% of the global freshwater supplies, global food production is expected to double in the next 50 years (Jury and Vaux Jr., 2007). Meanwhile, while equitable access to water exacerbated by anthropogenic climate change and increasing privatization of water resources is a key concern for sustainability management, political-economic and corporate power over water management decisions continue to trump water justice needs (Falkenmark, 2013; Sultana, 2018; Joy et al., 2014). The stressors of human society on global water supplies have become so great that the planetary boundary of *freshwater change* for a safe operating space for humanity was crossed as per the 2023 update, indicating a water crisis that parallels in magnitude that of the climate crisis (Richardson et al., 2023; Bunsen et al., 2021).

Like other crises of the Anthropocene, the global water crisis has led to the emergence of innovative approaches to science and management and a realization of the limits to growth among economic development organizations (Meadows et al., 1992; Pahl-Wostl, 2007; WEF, 2011; Hoff, 2011). In 2011, The World Economic Forum cited water as "the only natural limit for economic growth" and promoted the water-energy-food (WEF) nexus as a science and management model to enhance water security for global corporate industries to ensure sustainable economic growth (WEF, 2011). The WEF nexus was also promoted at the Bonn 2011 Conference which was a collaborative event of the World Economic Forum, the World Wildlife Fund, and the International Food Policy Research Institute that sought to "contribute to the run-up to" the 2012 United Nations Conference on Sustainable Development – Rio+20 (IISD, 2024). The background paper for the Bonn 2011 conference, *Understanding the Nexus,* drew heavily from socio-ecological systems science and explained that nexus approaches can facilitate resource sector integration at multiple scales and interdisciplinary collaboration (Hoff, 2011; Holling et al., 1986). The paper, and the concept of the WEF nexus, provided key policy objectives for the sustainable development goals (SDGs) that materialized from the Rio+20 international sustainability development agreement – the Millennium Development Goals (Zukang, 2012).

While Allouche and colleagues (2015; 2019) identify managing the WEF nexus as "one of the grand challenges of the 21st century" and caution that the concept of the nexus is immature, they and others warn that the sustainability movement has been coopted by development organizations who promote the WEF nexus for sustainable "development" to ensure continued economic growth (Allouche et al., 2015; Lélé, 1991; Wiegleb and Bruns, 2018). The result – WEF nexus framings being based on a neoliberal water security agenda to attain food and energy security to satisfy the demands for infinite economic growth (Leese and Meisch, 2015). Further, the economic rationale framing water quantity as the primary concern for WEF nexus research and management has resulted in positivist approaches dominating research and severe research gaps for tending to sustainability issues of inequity and environmental degradation stemming from nexus processes (Simpson and Jewitt, 2019; Bruns et al., 2022; Allouche et al., 2015; Liu et al., 2018; Albrecht et al., 2018; Leese and Meisch, 2015). Within conventional framings for WEF nexus research, dynamics of political economic power shaping management decisions and issues of environmental justice get placed on a backburner or omitted entirely (Allouche et al., 2015; 2019; Sultana, 2018).

2.2 Theoretical foundations and conceptualization of the WEF nexus

To attend to issues of social inequity and environmental degradation stemming from nexus processes, critical and social science approaches are needed (Bruns et al., 2022; Allouche et al., 2019; Wiegleb and Bruns, 2018; Albrecht et al., 2018). Moon and Blackman (2014) explain that social science approaches to research are needed for sustainability science because positivist approaches alone do not provide an application for emancipation or liberation from social structures of power. Likewise, Lövbrand and colleagues (2015) explain that, to facilitate the political mobilization needed to meet sustainability challenges, scientists should refrain from "adjusting to standardized research agendas" and that critical research can facilitate the scientific breakthroughs needed for social change. Accordingly, to tend to gaps in nexus research and promote sustainability management success, this research conceptualizes the WEF nexus as a socio-environmental system while joining the limits to growth with Marx's metabolic rift theory as its theoretical frame to investigate water quality in a rural industrialized WEF nexus (Figure 2.1).

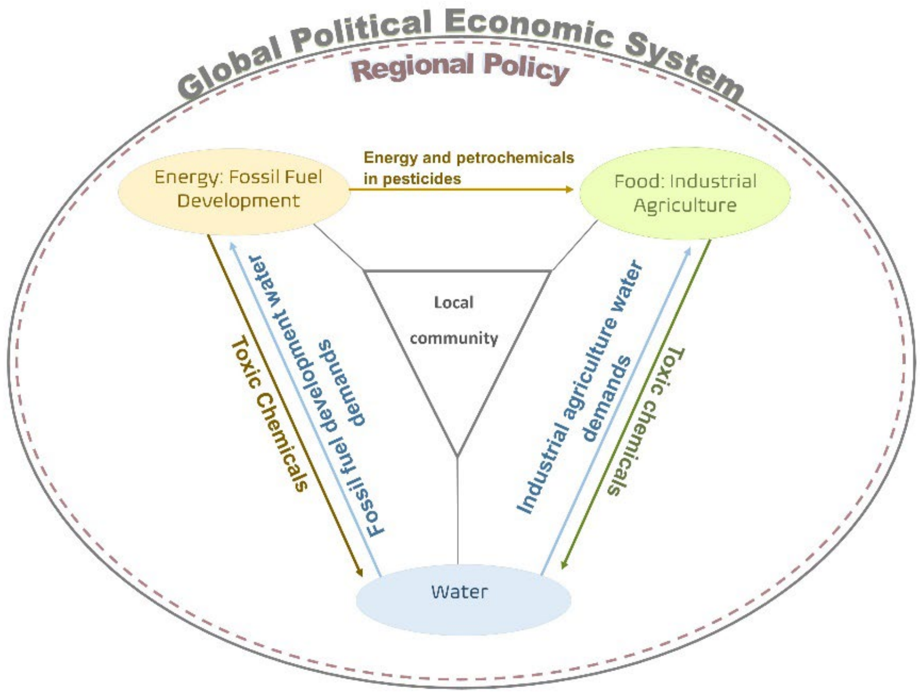

Figure 2.1 The rural water-energy-food nexus within the context of the global economic system based on infinite economic growth and industrial expansion. Regional policy prioritizes demands for economic growth which results in drawdown of water at rates faster than can be replenished and the co-occurrence of industrial chemicals in water. Figure by author, inspired by Lawford, 2019

The rural WEF nexus was chosen as the focal system for critical reasons. As representative of the WEF nexus, industrial agriculture and fossil fuel development are rural industries that increasingly occur in the same areas and continue to expand (Measham et al., 2016; Rockström et al., 2014). Meanwhile, the demands for energy and food within the broader market rationale of the global economic system are contradictory to ecological limits to industrial growth, making the rural WEF nexus an essential focal point for WEF nexus research for sustainability management (Meadows et al., 1992; Vargas et al., 2023). For example, while industrial agriculture is a significant driver of global change crises and trajectories towards exceedance of the planetary boundaries, the continued reliance on fossil fuels for agricultural production, domestic and global energy security, as well as a multitude of petrochemical industrial products supported by the rapid expansion in unconventional oil and natural gas development (hydraulic fracking) exemplifies the rural WEF nexus at the advanced stages of development based on capitalist industrialization (Black et al., 2021; Foster et al., 2010; Klein, 2007; Meadows et al., 1992; Rockström et al., 2009; 2014). Moreover, while the demographics of individuals living in rural regions represent low-income and minority communities, fewer resources are often available to address environmental toxicity related to industrial development in rural areas (Medina-Santana et al., 2020; London et al., 2021).

The theoretical frame provides a holistic, interdisciplinary, approach to explain how the system is functioning as it bridges the quantitative-qualitative divide while furnishing the needed critical approach to WEF nexus research (Anderies et al., 2013; Bruns et al., 2022). The limits to growth was a collaborative project of MIT's Club of Rome that intended to develop mathematical models of social behavior creating outcomes of environmental degradation following the great acceleration of industry post WWII (Meadows et al., 1972; McNeill and Engelke, 2014). The theoretical model is based on the tenet that Earth is a closed system with finite natural resources and pollution sinks thus having measurable threshold limits for industrial growth to ensure sustainability (Meadows et al., 1992). Meadows and colleagues (1992) explain that, "there are limits to the rates at which industrial waste can be emitted without harm to people, the planet, or Earth's processes of absorption, regeneration, and regulation" and that for pollution to be sustainable, the rate of emission and ecosystem throughput can be no greater than the rate at which that pollutant can be recycled and/or rendered harmless (Meadows et al., 1992). This provides a contradiction between the current economic system based on infinite economic growth and Earth's finite pollution sinks (Meadows et al., 1992).

Meadows and colleagues (1992) explain that "capital" is an engine for industrial growth that tends to increase exponentially, though they also hinge population growth to the problem which has led to critiques of the theory. Critiques of the limits to growth align with critiques of nexus research methods and conceptualization. For example, Mehta and colleagues (2019) explain the problematic nature of the concept of "scarcity" as providing justification for enclosure of the commons and neo-Malthusian population control tactics which have been based on racial stereotyping. Still, the models of the limits to growth have provided important socio-environmental systemic explanations for ecological degradation such as atmospheric concentrations of carbon dioxide as related to global warming, increasing levels of heavy metals in water and ecosystems due to industrial expansion, and systemic feedbacks important for sustainability management (Meadows et al., 1972; 1992). This research thus recognizes it as an important quantitative basis for explaining environmental degradation stemming from nexus processes – a primary gap in WEF nexus research for sustainability management (Albrecht et al., 2018).

Marx's metabolic rift theory offers the needed political economic explanations for the contradictions between capital accumulation and socio-ecological sustainability that the limits to growth and WEF nexus framings lack. For example, the theory describes capitalism as being reliant on a social structure of inequality where exploitation of the working class and the environment provides for the accumulation of wealth by those in power (Lynch et al., 2017; Foster, 1999). Profits (surplus value) are attained by the labor of workers over the wages they are paid (Lynch et al., 2017). To ensure capital accumulation continues indefinitely, increasingly intensive labor and environmental exploitation, mechanization, and use of chemicals are required (Schnaiberg, 1980; Clark et al., 2022; Lynch et al., 2017). This process produces external costs (negative externalities), such as environmental pollution and related health impacts, social inequity and uneven development, and global ecological systemic destruction, all of which increase over time (Foster, 1999; Lynch et al., 2017; Klein, 2007). These external costs represent the metabolic rift of capitalism's socio-ecological crises, or contradictions, that occur as industrial development expands and ecological disorganization increases (Foster, 1999; Foster et al., 2010; Napoletano et al., 2019). The metabolic rift theory thus provides a critical social science method to explain socio-environmental degradation stemming from nexus processes – also a primary gap in WEF nexus and sustainability research (Allouche et al., 2019; Bruns et al., 2022; Wiegleb and Bruns, 2018; Albrecht et al., 2018).

2.3 Methodology and case context

This research tests the theoretical assumptions of the limits to growth and Marx's metabolic rift theory by investigating the local outcomes of industrialization of the WEF nexus using a case study of pollution exposure risk. While Yin (2018) highlights that the "distinctive need for case studies arises out of the desire to understand complex phenomena" and that case studies are appropriate for tracing operational processes over time, Ravitch and Carl (2016) highlight that case studies are "useful when the researcher seeks to understand an issue of problem using a case as an illustration." Further, case studies provide the ability to investigate mechanisms for, and societal underpinnings of, unsustainability as they provide a method to approach a case within its geographical and historical context (Ravitch and Carl, 2016).

Pollution exposure case studies provide an important contribution to WEF nexus research for sustainability management. For example, pollution exposure risk assessments provide an essential method for investigating the local outcomes, or risks, of industrial development (Zhao et al., 2022; Nieuwenhuijsen et al., 2006). Considering the growing concern for a global groundwater pollution crisis and pollution source loads in industry-intensive areas, Zhao and colleagues (2022) conducted a groundwater pollution risk assessment and found that at least 70% of the case study region was at high risk for exposure to water pollution (Zhao et al., 2022). Similarly, other case studies in rural industry-intensive areas have identified groundwater pollution as a serious risk for human health as well as a source of social disparities (Shrestha and Luo, 2017; McMahon et al., 2019; Balazs et al., 2011; 2012; Luo and Zhang, 2009). Considering the trajectory of development continues to be capitalist industrialization and the focus of WEF nexus research and management has primarily been based on resource security as opposed to environmental quality, pollution exposure risk assessments represents a critical gap WEF nexus research for sustainability management (Krausmann et al., 2008; Wallerstein, 2000; Harvey, 2005; Simpson and Jewitt, 2019; Wiegleb and Bruns, 2018).

Drawing from the theoretical frame, this research conceptualizes the nexus as a socio-environmental system operating within the context of the broader political-economic system while also within the constraints of local ecological renewal capacity. The case study centers in Kern County, California. Located in the southernmost portion of California's San Joaquin Valley (Figure 2.2), Kern County bears the cumulative impacts of intense rural industrial development, with industrial agriculture and fossil fuel development being the leading industries (London et al., 2021). Both industries are of colonial origin and follow a typical historical development trajectory towards industrialization, making Kern County an essential case of the nexus, especially considering the path towards development continues to be capitalist industrial development. Due to its intense rural industrial development and dependence on the production and export of fossil fuel and agriculture for income, Kern County has been characterized as having a resource curse as well as being a fossil fuel and environmental sacrifice zone (Michieka and Gearhart III, 2018; Chandrasekaran et al., 2021). Intersections of these industries with water within the context of never-ending economic growth provide a bleak outlook for sustainability. Moreover, being within a Mediterranean climate zone, water resources are quickly diminishing, partially attributed to the demands of these industries, each notorious for unsustainable water consumption (Almaliki et al., 2022; Keenan and Krannich, 1997)

Figure 2.2: The location of Kern County within California. Map by author

Branded as the engine of the US due to its role in growing domestic roots of the industry, fossil fuel production for profit in Kern County began in the 1860's (Trout et al., 2018). While the Midway-Sunset oil field produced a quarter of the global oil supply by 1923, it remains one of the top production sites in the US and is the largest oil field in California. Known as California's fossil fuel capital, Kern County produces about 367,000 barrels oil per day, provides 70% and 18% of the state's oil and natural gas respectively, is the second largest fossil fuel producer in the lower 48 and third in the US providing 5% of US and 1% of global crude oil supply (Thuot, 2014; Mernit, 2019). Technological advances in fossil fuel extraction, such as high-pressure steam injection and hydraulic fracking, incorporate and/or produce dangerous chemicals as biproducts that threaten groundwater supplies, wildlife, and human health (Elliot et al., 2017; Lopez, 2015). While there are now more than 100,000 fossil fuel development wells in Kern County, there have been many oil spills, some of which have been catastrophic and have resulted in litigation while feeding the fire for local social movements against hydraulic fracking and ongoing permitting of new wells (Kane, 2020; Mernit, 2019; Makinen and Wilson, 2019).

The historical development of Kern County's agricultural industry mirrors the development of its fossil fuel industry. Fed by colonial-era immigration, agricultural development in the county began during the period of the gold rush as mining and ranching were the ambitions of colonial pioneers and development tycoons (Jelinek, 1999; Arax and Wartzman, 2003; Turner, 1981). Rancheros and small farms of the county and the broader San Joaquin Valley provided the food supply for mining communities until congressional actions led to broadscale privatization of lands, concentration of land ownership by white elites, and the development of industrial agriculture as we know it today (Jelinek, 1999). Often termed white gold, cotton, among other crops and livestock commodities, became a key export commodity contributing to Kern County's and California's economic growth (Turner, 1981; Jelinek, 1999). While Kern County is now a top agricultural producer in the US with crops exported to 96 countries, it produces the most lucrative crops (i.e., almonds, dairy, grapes, and pistachios) in California (CDFA, 2022). While drawdown of groundwater and rerouting of streams for industrial agriculture alone could be analyzed using the metabolic rift, Kern County's agricultural lands receive more than 20 million pounds of pesticides each year (CA DPR, 2021). Sadly, water has become so depleted that oil and gas development wastewater is being applied to agricultural crops, threatening possible exposure of agricultural workers and residents to co-occurring pollutants of industrial agriculture and fossil fuel development in the air and local water resources (Siu and Akhundjanov, 2020; Shariq, 2013). Other concerns associated with using fossil fuel development wastewater for agricultural irrigation include degradation of soil quality and crop production as well as bioaccumulation of toxic chemicals (Siu and Akhundjanov, 2020; Shariq, 2013).

The research questions and hypothesis of this research are based on the theoretical frame and the advanced stage of industrial development of Kern County and are as follows.

(1) What evidence is there that the limits to growth (industrial development) have been exceeded in the WEF nexus of Kern County and what insights can be drawn from the theoretical frame to direct WEF nexus science and sustainability management?
    a. What chemicals directly related to industrial agriculture and/or fossil fuel development are present in Kern County's tap water and have those chemicals surpassed safety threshold goals?
    b. Are individuals within proximity to nexus industrial development areas at increased risk for exposure to nexus industrial chemicals in tap water?

Hypothesis: The limits to growth have been exceeded and individuals who are within proximity to nexus industries are at greater risk for exposure to nexus industrial chemicals in tap water.

2.3.1 Spatial Analysis Methods

Following Mennis and Heckert (2018), Mennis (2000), and Meng (2015), this research uses the distance-based approach of buffer analysis to delineate the spatial characteristics of pollution exposure risk resulting from the limits to growth in the WEF nexus of Kern County. Buffer analysis includes the creation of a new polygon around points, lines, or areas on a map to indicate areas of pollution exposure risk and/or to compare data inside vs outside the buffer zone (Chakraborty, 2017). Buffer analysis was chosen considering the limitations of spatial coincidence, plume-based, and cumulative exposure analyses which have been noted for inefficiencies such as accounting for boundary or edge effects, statistical bias related to the modified area unit problem, and limitations of data constraints (Chakraborty, 2017; Chakraborty and Armstrong, 2013; Mennis, 2000; Sexton and Linder, 2018). A limitation of the distance-based, buffer analysis, approach is that flows of pollution are not accounted for (Chakraborty, 2017).

Buffer distances for nexus industries were informed by environmental toxicology case studies. For example, research has shown that drinking water wells located < 1 km from oil and gas development activities are likely to become contaminated and that individuals living within 2 km of oil and gas development wells may experience adverse health impacts from exposure to related chemicals in water (Rabinowitz et al., 2015; Meng, 2015; Wollin et al., 2020). To create the fossil fuel risk zone, open-source spatial data of oil and gas development wells in California were imported into ArcGIS Pro (V 3.1.0) (CA Department of Conservation, 2023). Buffer analysis was used to create a risk buffer of 2 km around active and idle wells. The dissolve tool was used to merge buffers that overlapped to create fossil fuel development risk zones. Research has shown that, due to soil properties, the valley portion of Kern County has a high probability for pesticide contamination of groundwater (Teso et al., 1996). Following from this, California's Department of Pesticide Regulation open-source spatial data was used to create a risk buffer of 0.1 km around Kern County agricultural lands that receive the highest applications of pesticides (APC, 2019; CA DPR, 2021). These methods provided for the creation of three distinct risk zones: 1) fossil fuel 2) agricultural 3) a combination risk zone with major overlaps between both nexus industries.

To validate the risk buffer zones and to provide a response to the research questions and hypothesis, a database was created containing Kern County zip codes as well as levels of several chemicals directly related to industrial agriculture and/or fossil fuel development in tap water for each zip code. Literature review of environmental toxicology case studies and online data sources were used to pinpoint nexus industry chemicals of concern. Chemicals of focus include Total Trihalomethanes (TTHMs), Hexavalent Chromium (Chromium-6), Haloacetic Acids (HAA9), arsenic, 1,2,3-Trichloropropane, 1,2-Dibromo-3-chloropropane (DBCP), and nitrate (EWG, 2021; Balazs et al., 2012; Rabinowitz et al., 2015; Wollen et al., 2020). Data for the levels of these chemicals in Kern County's tap water were retrieved using Environmental Working Group's (EWG) online open-source tap water quality search tool (EWG, 2021). The database containing Kern County's zip codes and the levels of the chemicals of interest per zip code were imported into ArcGIS Pro for spatial characterization.

California's public health goals (PHGs) were used as safety thresholds for spatial characterization of the chemicals in tap water. While chemical level exceedance of PHG safety thresholds in tap water would signify the exceedance of the limits to growth, nexus industry pollution accumulation in tap water would also represent the metabolic rift. California's PHG safety thresholds were chosen as the thresholds for the limits to growth considering these thresholds are based on science as opposed to being set according to monetary cost-benefit analysis. For example, legal limits for chemicals in water are often set (much) higher than PHG safety thresholds out of concern for the monetary cost of regulation and/or remediation (EPA, 2022; EWG, 2021). This is exemplified by the recent regulation for levels of chromium-6 in drinking water in California which was set at 10 ppb as opposed to the PHG safety threshold of 0.02 ppb due to the projected costs for remediation and filtration (EWG, 2021). California's Office of Environmental Health Hazard Assessment (OEHHA) sets PHG safety thresholds for industrial chemicals in drinking water to avoid adverse health impacts assuming that an individual would be drinking that water daily for 70 years (OEHHA, 2023). For chemicals that are known to cause cancer, the OEHHA applies the "one-in-a-million risk level" whereby "not more than one person in a population of one million people drinking that water for 70 years would be expected to develop cancer as a result of exposure to that chemical" (OEHHA, 2023). Levels of each chemical were symbolized using a bar graph. Measurements that were equal to or below the PHG safety threshold were excluded from the map.

While the spatial analysis provides for investigating the likelihood, or risk, for exposure to nexus industry-related chemicals, pathways for exposure and actual health risks are also included in the results (Table 2-1). Comparisons were made between levels of nexus-related chemicals inside vs outside the risk buffer zones as well as between risk buffer zones using maps as well as by averaging levels of chemicals for zip codes in each risk zone vs outside and between the risk zones. These methods provided the ability to not only validate the risk zones and to ascertain the validity of the hypothesis and theoretical assumptions, but also investigate the spatial association of chemicals in tap water with nexus industrial pollution sources. The risk zones also provide locations to conduct further research to investigate social dynamics in the rural WEF nexus of Kern County important for sustainability management**.**

Table 2-1: Chemicals in Kern County's tap water that have linkages to fossil fuel development and industrial agriculture, health risks associated with the chemicals, and California's public health goal safety thresholds. Sources: Balazs et al., 2012; Rabinowitz et al., 2015; Wollin et al., 2020; EWG, 2021.

Chemical	WEF Nexus industry relation of chemical	Health risks of chemical	CA public health goal safety threshold
Total Trihalomethanes (TTHMs)	Fossil fuel development	Liver, kidney, and intestinal tumors. Carcinogen. Pregnancy: Spontaneous miscarriage, cardiovascular and neural tube defects, low birth weight.	0.15 ppb
Haloacetic acids (HAA9)	Fossil fuel development	Pregnancy - Genotoxic (induces mutations). Carcinogen	0.06 ppb
Chromium-6	fossil fuel development and industrial agriculture	Carcinogen. Neurotoxin.	0.02 ppb
Arsenic	Industrial agriculture and fossil fuel development (occurs naturally in soil)	Carcinogen: Bladder, lung, and skin cancer	0.004 ppb
1,2,3-Trichloropropane (1,2,3-TCP)	Industrial agriculture	Carcinogen	.0007 ppb
Nitrate	Industrial agriculture	Infant shortness of breath/blue baby syndrome. Carcinogen.	1.0 ppm
1,2-Dibromo-3-chloropropane (DBCP)	Industrial agriculture	Male sterility and testicular damage. Carcinogen	.003 ppb

2.4 Results and discussion

The results back the theoretical frame and hypothesis. Nexus industry-related chemicals in Kern County's tap water far exceed safety thresholds. While residents of Kern County, particularly those living in the valley region, are at risk for exposure to dangerous levels of nexus industrial chemicals in tap water, those within the risk zones are at far greater risk. The map figures below indicate the spatial association of nexus industrial chemicals in tap water with their respective industry sources, which are elaborated on below. Table 2 shows the average level for each chemical inside versus outside the risk zones as well as average levels for nexus-related chemicals in areas where the risk zones overlap.

2.4 Results

Nexus industry-related chemicals in Kern County's tap water far exceed safety thresholds. While residents of Kern County, particularly those living in the valley region, are at risk for exposure to unsafe levels of nexus industrial chemicals in tap water, those within the risk zones are at far greater risk. While map figures 3-7 indicate the spatial association of nexus industrial chemicals in tap water to their respective industry sources, table 2-2 shows the average level for each chemical inside vs outside the risk zones as well as average levels for nexus-related chemicals in areas where the risk zones overlap. The results back the theoretical frame and hypothesis, which is elaborated on in the discussion section below.

Table 2-2: Average levels of nexus industry-related chemicals in tap water for each risk zone, outside of the risk zones, and the public health goal safety threshold for each chemical. Data for table: USCB, 2021; EWG, 2021; OEHHA, 2024.

Chemical	Average level in tap water - industrial agriculture risk Zone	Average level in tap water - fossil fuel development risk zone	Average level in tap water - combination risk zone	Average level in tap water - outside of risk zones	CA public health goal safety threshold
TTHMs (ppb)	4.4	27.3	12.9	7.2	.015
HAA9 (ppb)	2.4	27.9	4.9	0	.06
Chromium-6 (ppb)	4.17	.64	1.02	0	.02
1,2,3-TCP (ppb)	.014	.0003	.038	0	.0007
DBCP (ppb)	.01	.00003	.004	0	.003
Arsenic (ppb)	3.7	1.38	8.8	4.08	.004
Nitrate (ppm)	5	1.9	2.3	1.2	1

2.4.1 Fossil Fuel Development Water Pollution Exposure Risk Zone

TTHMs and HAA9 are two major chemical groups of concern for water quality in regions deeply impacted by fossil fuel development. TTHMs are the combination of four chemicals (chloroform, bromodichloromethane, dibromochloromethane, and bromoform) that form as biproducts of industrial processes and municipal water treatment (Wollen et al., 2020; States et al., 2013). Similarly, HAA9 represents the "sum mass concentration of nine haloacetic acid species" which also form as biproducts from industrial processes and water treatment due to reactions between disinfectants, such as chlorine, and bromide (Parvez et al., 2019). TTHMs and HAA9 are linked to hydraulic fracking as these chemicals have been shown to form during fracking events, after disposal of fracking wastewater, and/or during the treatment of fracking wastewater (Wollen et al., 2020).

The increase of TTHMs and HAA9 in Kern County's tap water with proximity to the fossil fuel development risk zone indicates the limits to growth of the fossil fuel industry have been exceeded and that pollution is being produced from nexus processes. The average levels of TTHMs and HAA9 in tap water within the fossil fuel risk zone were 27.3 ppb and 27.9 ppm respectively while they averaged 7.2 ppb and 0 ppb outside the risk zone (Figures 2.3 and 2.4). As explained by the limits to growth, the PHG safety threshold for TTHMs and HAA9 in tap water being surpassed to the extreme degree to which they have represents an "overshoot" of the abilities of Kern County's ecosystems to filter and recycle toxins (Meadows et al., 1992). Meadows and colleagues (1992) warn that when such overshoots occur, the system needs time to recover by reducing the inputs of toxins, otherwise a systemic collapse may be on the horizon. These theoretical insights parallel those of the metabolic rift theory. For example, the technological advances to increase the capacity for fossil fuel extraction in Kern County exemplifies the function of the system under the capital accumulation. As natural resource exploitation intensifies, the metabolic rift materializes in the form of external costs (Foster, 1999).

In this case, water pollution. The results of the GIS analysis indicate that, due to an overshoot of the ecosystem's capacity for ecosystem renewal, the metabolic rift grows deeper with proximity to fossil fuel extraction locations in Kern County. These results provide evidence additional to those of climate change applications of the limits to growth and the metabolic rift that decarbonization as an aspect of social change is needed to protect human health and the environment (Foster et al., 2010; Meadows et al., 1992; Capellán-Pérez et al., 2015).

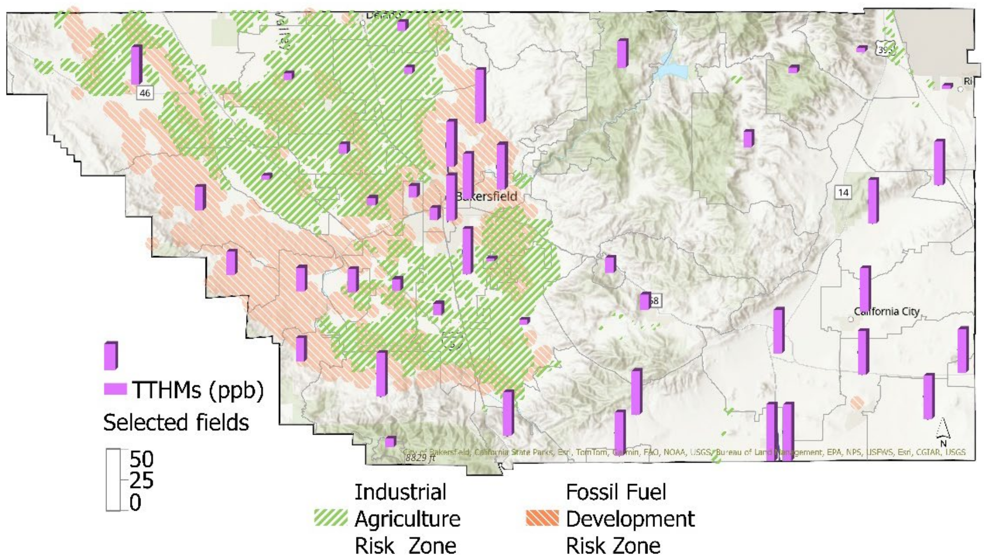

Figure 2.3: Map shows the levels of total trihalomethanes (TTHMs) in tap water throughout Kern County. Zip code areas that show a bar graph symbol have TTHMs in tap water exceeding the PHG safety threshold of 0.15 ppb.

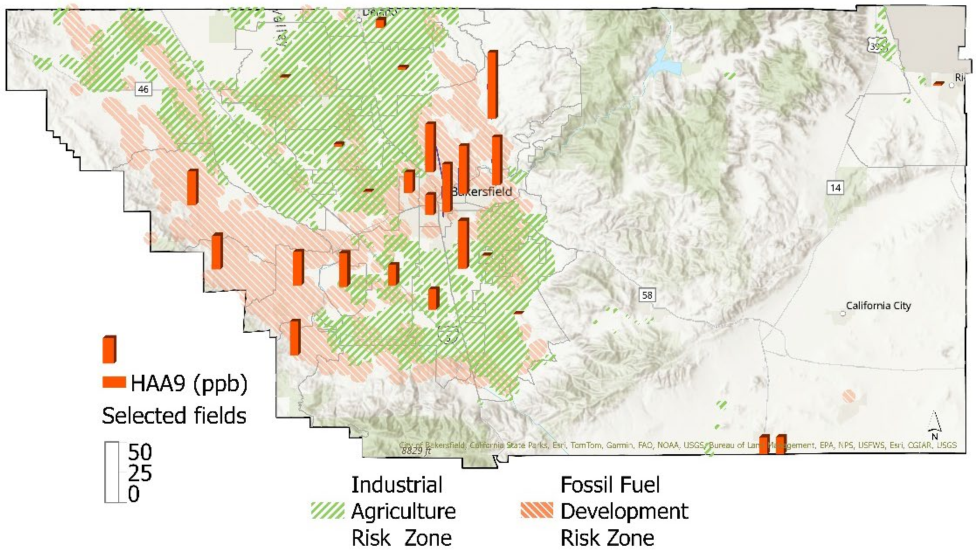

Figure 2.4: Map shows the levels of haloacetic acids (HAA9) in tap water throughout Kern County. Zip code areas that show a bar graph symbol have HAA9 in tap water exceeding the PHG safety threshold of 0.06 ppb.

The metabolic rift also provides explanations for linkages between industrial development and humans as a socio-environmental system, thus again exemplifying the theory's important supplement to the explanations provided by the limits to growth. For example, the negative externalities of capitalism include health impacts related to industrial pollution (Foster, 1999; Lynch et al., 2017). Jason Moore (2015) uses the metabolic rift theory to exemplify the metabolic connections between humans and Earth systems and the contradictions of capitalism for sustainability while explaining that humanity and environments "are not independent but interpenetrated at every level, from the body to the biosphere." As shown in Table 2.1, TTHMs are carcinogenic and have been linked to the formation of liver, kidney, and intestinal tumors while also providing dangers for pregnancy such as spontaneous miscarriage, cardiovascular and neural tube defects, and low birth weight (EWG, 2021). Accordingly, research has shown that women living in regions of fossil fuel development who are most exposed to hydraulic fracking wastewater had higher incidence of low birth weights as well as premature labor (Wollen et al., 2020). HAA9 is also a carcinogen and has been found to induce fetal mutations while also being cytotoxic (causes cells to die) and genotoxic (causes DNA damage) (Parvez et al., 2019). While Map 2.3 shows that nearly all of Kern County tap water represents the risk of exposure to this dangerous chemical, and thus demands further investigation, levels in the valley region are higher in the fossil fuel development risk zone. This indicates the fossil fuel industry is an important source for this chemical in tap water. TTHMs and HAA9 exposure pathways are mainly inhalation and dermal absorption so occupational exposure as well as household activities such as cleaning and bathing represent pathways for exposure risk (Levin et al., 2023).

2.4.2 Industrial Agriculture Risk Zone

Industrial agriculture is the largest contributor to water pollution, thus playing a major role in the global water crisis (Mateo-Sagasta et al., 2018; Horrigan et al., 2002). There are three chemicals of focus for the agricultural water pollution exposure risk zone in this case study – nitrate, 1,2,3-

TCP, and DBCP. While the occurrence of nitrate in tap water in agricultural areas is mainly linked to the use of synthetic nitrogen fertilizers and livestock, 1,2,3-TCP and DBCP in tap water is linked to the legacy use of these chemicals as soil fumigants (Balazs et al., 2011; Burow et al., 2019). Focusing first on nitrate, like TTHMs, nitrate levels far exceed the PHG safety threshold throughout much of the county yet increase with proximity to the industrial agriculture risk zone (Figure 2.5). While the safety threshold for nitrate is .0007 ppm, the average level in tap water within the agricultural risk zone was 5 ppm versus averaging 1.2 ppm outside of the risk zone.

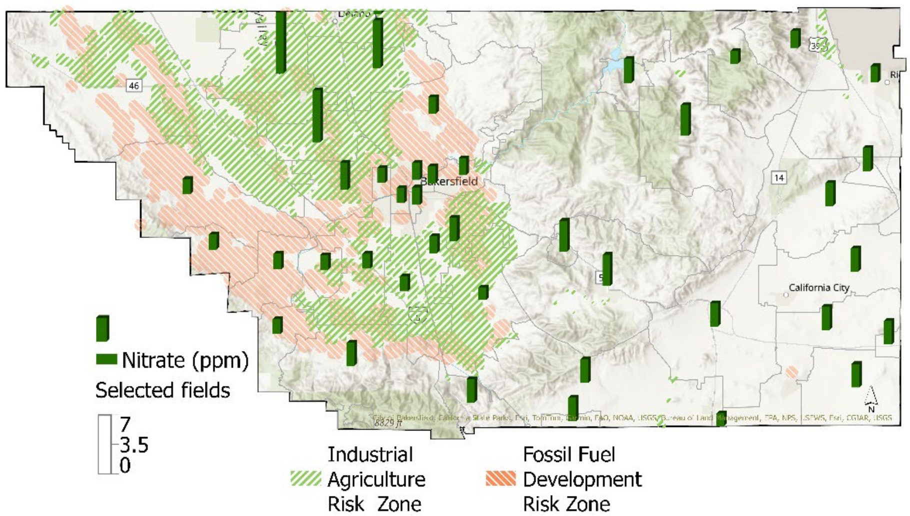

Figure 2.5: Map shows the levels of nitrate in tap water throughout Kern County. Zip code areas that show a bar graph symbol have nitrate in tap water exceeding the PHG safety threshold of 1 ppm.

While levels of nitrogen in Kern County's tap water strongly indicate an overshoot of the capacity of the system for ecosystem renewal, as explained by the limits to growth, Marx's metabolic rift theory provides political economic explanations for this facet of Kern County's water pollution crisis. Building upon the work of others and collaborating with the soil science community during the industrial revolution, Marx observed that rural lands were increasingly being utilized to grow food for expanding urban areas which was resulting in the depletion of soil nutrients at rates faster than could be replenished (Foster, 2000). Marx noted scientific advances in industrial agriculture (i.e., synthetic fertilizer, pesticides, machinery) provided technological fixes to increase agricultural output and satisfy the demand for urban industrial growth but that these fixes did not provide a cure for the "exhaustion of the land" being caused by industrial agriculture (Foster, 1999). Marx compared the changes in soil chemistry and losses of soil fertility to the systemic relations between human society and nature under capitalism (Foster, 1999). This process, referred to as the antagonism between town and country, represented the historical materialist emergence of the metabolic rift as uneven geographical development and rural development crises of capitalism began to unfold due to industrial agriculture intensification and expansion (Foster, 2000; Napolitano et al., 2019). Considering Kern County is an export economy and the intense development of agriculture in the region, the application of nitrogen to agricultural lands to maintain economic growth in the rural industrialized WEF nexus provides a quintessential example of the metabolic rift and the antagonism between town and county.

The presence of the legacy pesticides, 1,2,3-TCP and DBCP, in Kern County's tap water indicate another important facet of the water pollution crises in the rural industrialized WEF nexus of Kern County. 1,2,3-TCP is an important representation of the WEF nexus considering it was a petrochemical created by Shell Oil and Dow Chemical Company for the purpose of soil fumigation in industrial agriculture (Burow et al., 2019; Hauptman and Naughton, 2021). Now outlawed in California, 1,2,3-TCP is a potent carcinogen that persists in ecosystems and groundwater as it does not bind to soil and is highly stable (Hauptman and Naughton, 2021). While the safety threshold for 1,2,3-TCP is .0007 ppb, its average in tap water in the agriculture risk zone was .014 ppb and was not detected in tap water outside of the three risk zones (Figure 2.6). DBCP, also a soil fumigant now outlawed in the United States, is a carcinogen while also being linked to male sterility, testicular damage, and spontaneous abortion (Lyer and Makris, 2010). While the safety threshold for DBCP is .0017 ppb, its average level in tap water in the agriculture risk zone was a magnitude greater at .01 ppb and was not detected in tap water outside of the three risk zones (Figure 2.7).

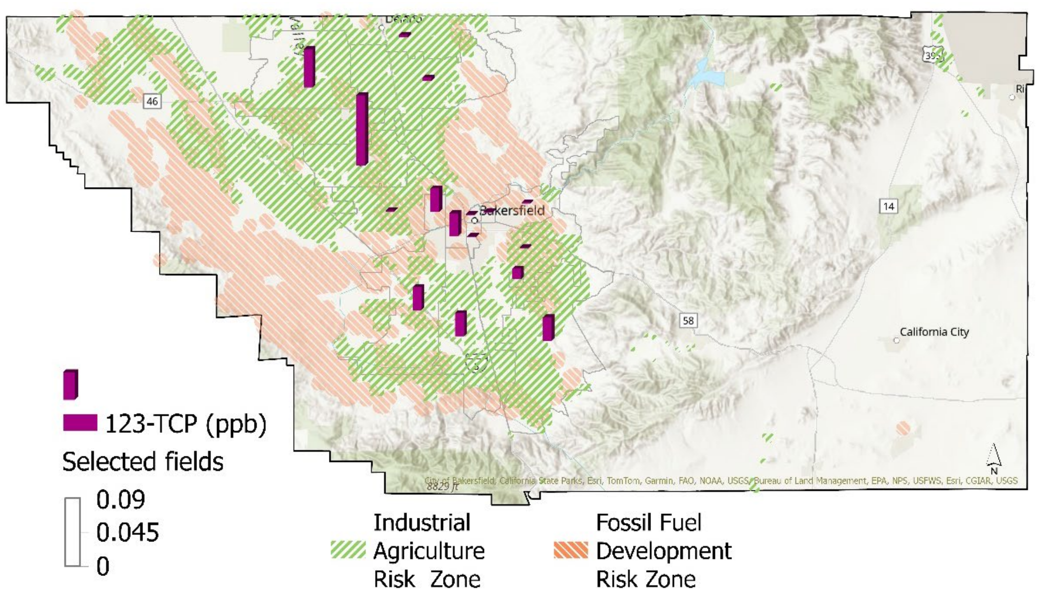

Figure 2.6: Map shows levels of 1,2,3-TCP in tap water throughout Kern County. 1,2,3-TCP was used in industrial agriculture from the 1950s-1970s as a soil fumigant. Zip code areas that show a bar graph symbol have 1,2,3-TCP in tap water exceeding the PHG safety threshold of 0.0007 ppb.

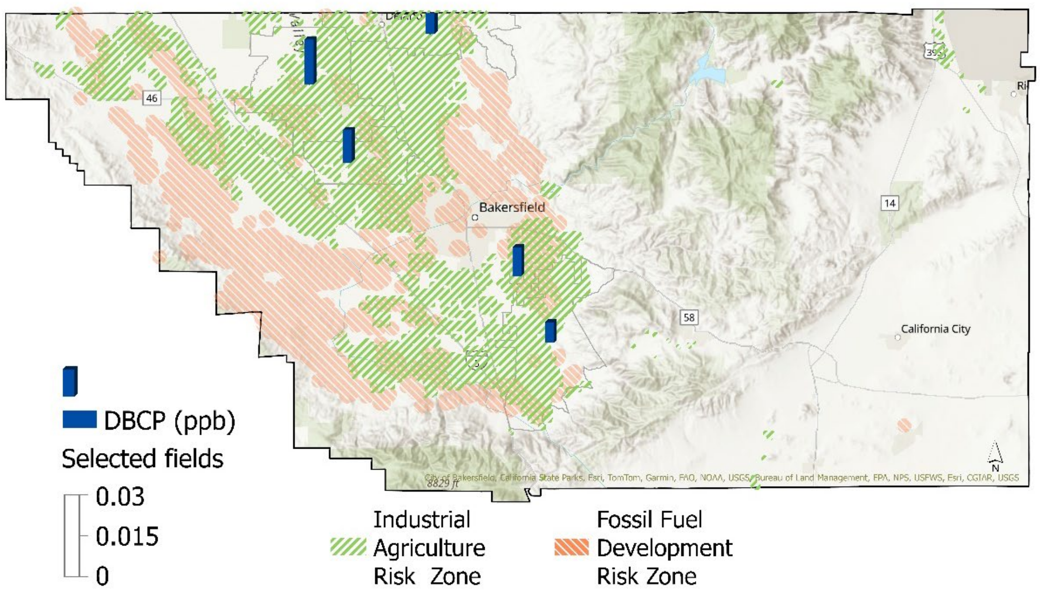

Figure 2.7: Map shows the levels of the DBCP in tap water throughout Kern County, the levels of which correlate to industry proximity. Zip code areas that show a bar graph symbol have DBCP in tap water exceeding the PHG safety threshold.

Exposure pathways for nitrate, 1,2,3-TCP and DBCP are drinking water, thus making tap water a risk for public health and the embodiment of the negative externalities of the industrialized WEF nexus (La et al., 1996; DHHS, 2017). While risks include cancer for each of these chemicals, nitrate is a risk for children as it causes infant shortness of breath and blue baby syndrome (Balazs et al., 2011; Burow et al., 2019). Accordingly, in relation to trade-offs in the scheme of global development and the antagonism between town and county is the risk of the embodiment of the negative externalities of capitalism in rural industrialized regions. This point backs calls for the need for more case studies of the WEF nexus that focus on environmental justice and the role of power in policy decisions (Allouche et al., 2019). While considered briefly below, externalities and the embodiment of pollution stemming from WEF nexus processes will certainly provide important aspects of such case studies. The agricultural industry represents a major power in development policy in the WEF nexus of Kern County considering Kern County is a top agricultural producer in the US and its income is supported by industrial agriculture export crops (CDFA, 2022).

2.4.3 WEF Nexus Industry Pollution Exposure Risk Overlap Zones

Several chemicals associated with fossil fuel development and industrial agriculture co-occur in the areas where the pollution exposure risk zones overlap. This provides a holistic representation of the rural industrialized WEF nexus as well as implications for these industries increasingly occurring in proximity to one another due to industrial expansion. A key implication is the compounded pollution exposure risk for individuals living in these areas. For example, while both 1,2,3-TCP and DBCP occur in tap water at levels that exceed the safety thresholds in regions where the risk zones overlap, the average for 1,2,3-TCP is highest in these areas at .038 ppb. If these industries continue to expand, the areas of overlap will increase as will the risk for exposure and related health impacts. This increasing risk in the rural industrialized WEF nexus is linked to a systemic mechanism explained by the limits to growth to be "erosion loops" associated with infinite economic growth (Meadows et al., 1992). Erosion loops represent a positive feedback in the system that causes a downward spiral of socio-environmental health akin to the metabolic rift. As industrial development expands, socio-environmental health becomes degraded as the rift deepens. Erosion loops can also be caused by the interaction of pollution with the local environment which results in the creation of more pollution (Meadows et al., 1992). The levels of arsenic and chromium-6 in tap water exemplify these erosion loops and the metabolic rift. Due to its use in industrial agriculture (i.e., pesticides, herbicides, and livestock antibiotics) while also occurring naturally in Kern County's soil, the presence of arsenic in tap water is linked to both industrial agriculture and fossil fuel development (Shariq, 2013; Punshon et al., 2017. Both industries disturb the soil and use water, making arsenic subject to biogeochemical reactions, weathering, and thus releases into local water resources (Shariq, 2013; Punshon et al., 2017; Ferguson and Gavis, 1972). While arsenic has a safety threshold of .004 ppb, it averaged 3.7 ppb within the agricultural risk zone, 1.38 ppb within the fossil fuel risk zone, and 8.8 ppb in regions with major overlaps of the fossil fuel and industrial agriculture risk zones (Figure 2.8). Thus, the erosion loop and the metabolic rift related to arsenic are of greater intensity in regions where both industries occur.

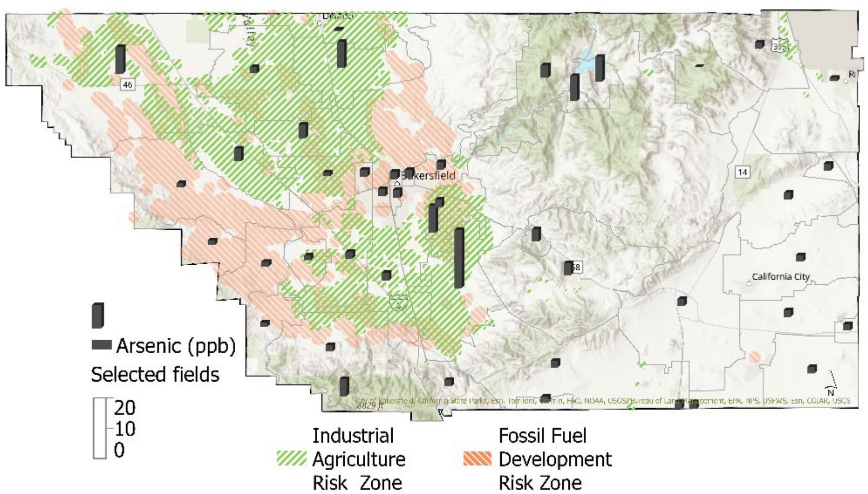

Figure 2.8: Arsenic levels in tap water throughout Kern County. Zip code areas that show a bar graph symbol have arsenic in tap water exceeding the PHG safety threshold.

Chromium-6 is linked to both nexus industries directly and indirectly. For example, while it is used as an anti-corrosive coating on pipes and mechanical parts in industrial processes, Chromium-6 has been shown to be present in fracking fluid and wastewater, case studies have shown increases in this toxic chemical in tap water in proximity to fracking (Wollin et al., 2020). Meanwhile, chromium-6 has been materializing in the water and soil of industrial agricultural areas of the San Joaquin Valley. As related to erosion loops, recent research has revealed that a complex biogeochemical process between industrial agricultural (application of pesticides and fertilizers) and the natural presence of chromium-3 in San Joaquin Valley soils is producing chromium-6 (Hausladen et al., 2018). While the safety threshold for chromium-6 is .02 ppb, its averaged 4.17 ppb in the agricultural risk zone, 1.02 ppb in the combination risk zone, and .64

ppb in the fossil fuel risk zone while not being detected in regions outside of the risk zones (Figure 2.9).

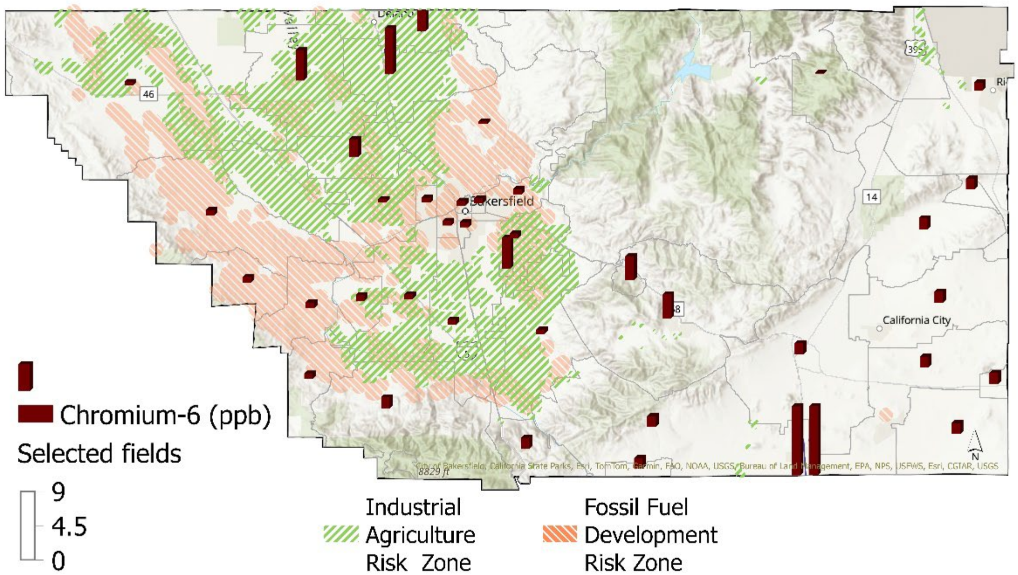

Figure 2.9: Chromium-6 in tap water throughout Kern County. Zip code areas that show a bar graph symbol have chromium-6 in tap water exceeding the PHG safety threshold of 0.02 ppb.

Health risks in the regions of Kern County where the pollution exposure risk zones overlap are more severe than other regions of the county, again signifying the metabolic rift. For example, while arsenic is linked to lung, skin, and bladder cancer, chromium-6 has a classification as a group one carcinogen by the World Health Organization while also being a neurotoxin, immune system suppressant, and the cause of “a variety of chronic, cardiovascular, and neurodegenerative diseases” (Sharma et al., 2022). The most common exposure pathway for arsenic is via consumption of contaminated groundwater, which is the source of tap water in many areas of Kern County (Balazs et al., 2012; London et al., 2021). Pathways for exposure to chromium-6 include oral, inhalation of steam, and dermal, making tap water a risk for exposure (Paustenbach et al., 2011). Also present in the risk zone overlap areas are the other risks identified above associated with fossil fuel development and industrial agriculture.

2.4.4 Further Considerations

This research shows that many safety thresholds have been crossed in the rural industrialized WEF nexus of Kern County. According to Meadows and colleagues (1992), this signifies a negative feedback in the system and a need for systemic change to reduce toxic inputs to the system. This view aligns with Marx’s metabolic rift theory as exemplified by those who employ it doing similar research who conclude that there is a dire need for social change. While the WEF nexus provides a microcosm for the initiation of social change, authors that employ the metabolic rift theory warn that technological fixes (ecological modernization) for management of crises of capitalism will only enable capitalist expansion (Napolitano et al., 2019; Harvey, 1978; 2005; 2006; 2010; 2018; Foster and Clark, 2009; Marx and Engels, 1888). This is particularly applicable and important for rural WEF nexus management considering conventional framings include economic growth objectives under the guise of sustainability (Allouche et al., 2015; Lélé, 1991; Wiegleb and Bruns, 2018). The result in WEF nexus research as related to sustainability management has been a "green modernization development discourse" whereby "powerful actors adopt and promote green narratives around long-standing modernization ideas" (Bergius and Buseth, 2019). While scrutiny of solutions, such as green modernization, for sustainability management in the WEF nexus is imperative for the social transformations needed to detoxify water, White and colleagues (2010) warn that rift scholarship has been narrowing possibilities for interdisciplinary engagement and that eco-social transformations depend on interdisciplinarity and co-production between "red-green thinkers." This point is especially relevant for sustainability management in rural regions considering the concentration of "red" thinkers in these areas of developed countries, such as the United States (Scala and Johnson, 2017). The process of eco-social change is a dynamic process that can be better facilitated by hybrid methodologies and thinking, such as provided by this research, to create a "good Anthropocene," but radical changes are needed (McPhearson et al., 2021; White et al., 2010).

From a multi-scalar perspective, this case study provides a stark outlook for the planetary boundaries and an important linkage between WEF nexus and planetary boundary research. While industrial agriculture is a well-recognized culprit of the exceedance of the *biogeochemical flows* (nitrogen/phosphorus) boundary, the 2023 update on the planetary boundaries now includes details on the *novel entities* boundary, which has been exceeded (Rockström et al., 2009; Richardson et al., 2023). Novel entities include synthetic chemicals and substances, including organic pollutants (Richardson et al., 2023). Several of the chemicals of focus in this case study fall under this category including TTHMs, HAA9, 1,2,3-TCP, DBCP, and chromium-6. While WEF nexus research and management is guided by the demand for quantities of water, as is the planetary boundary of freshwater change, water pollution stemming from WEF nexus processes in rural industrialized areas represents an important aspect of the *novel entities* boundary that needs further research. A key takeaway from this case study as related to the planetary boundaries and the metabolic rift is that irreversible damage may occur if changes are not implemented to slow and reverse key drivers pushing Earth systems to tipping points (Foster et al., 2010). Kern County is edging towards these tipping points.

There are a great number of options to slow and reverse key drivers pushing Earth systems to tipping points the rural WEF nexus provided by authors who employ the metabolic rift as well as those outside of rift scholarship. For example, Wittman (2009) uses the metabolic rift theory to explain the relation between industrial agriculture and global ecological degradation. For Wittman (2009), the rift represents not only environmental degradation but also the disruption of "the practice of agrarian citizenship." The social change needed to repair this rift is a food sovereignty model of agriculture founded in ecological sustainability (Wittman, 2009). Others using the metabolic rift recognize the antagonism between town and county and suggest urban agriculture as a social system change to mend the rift, which could also alleviate Malthusianist arguments for the limits to population growth in urban areas (McClintock, 2010; Dehaene et al., 2016).

Exemplary of work outside of rift scholarship is Escobar's (2015) review of transitions discourses which aims to start a holistic conversation about what is needed to move towards a sustainable society. Discourses include degrowth, post-development, Buen Vivir and the rights of nature, and biocentricity, all of which provide critical insights for management of the rural WEF nexus.

D'Alisa and colleagues' (2015) explain that degrowth "calls for the abolishment of economic growth as a social objective" and that it is associated with production and consumption downscaling to produce a smaller metabolism (D'Alisa et al., 2015). Following from their book, degrowth in the WEF nexus would provide for shifts away from an economic system based on valuation of gross domestic product (monetary value of goods and services produced within a country periodically) to one that values social and environmental quality such as environmental justice, equity, happiness, health, biodiversity, and community connectivity, thus aligning with Wittman's (2009) advice (Victor, 2015; Sekulova, 2015; Anguelovski, 2015; D'Alisa et al., 2015). Also highlighted in D'Alisa and colleagues' (2015) book is civil disobedience such as collective action and social movements to demand change. Collective action has been important for small changes in the nexus thus far in Kern County (Renou, 2019). For example, the Committee for a Better Arvin environmental justice group presented evidence of the health impacts residents were experiencing from fracking and demanded an ordinance to increase the distance between fracking wells and human habitations, commercial zones, and schools (Kane, 2020). The Committee for a Better Arvin has also been raising concerns for the impacts of pesticides and has been working with the US EPA and the California Water Resources Control Boards to reduce arsenic in tap water to below the EPA's standard of 10 ppb (Murillo, 2021).

Post-development, as opposed to representing an objective of making a hard exit from the economic system we live within, represents practices and views on planetary well-being based on cooperation (as opposed to competition), dignity, peace, equity, and bio-civilizations (Kothari et al., 2019). In their book "Pluriverse," Kothari and colleagues (2019) provide a post-development dictionary to encourage a transition in society which could be incorporated into nexus research and management. A post-development nexus and its management would be based on systems thinking and valuation of ecological wisdom, integrity, and resilience as well as social well-being and justice, among others. While Buen Vivir (living well), an Indigenous-led social movement, critiques conventional development and proposes the legal rights of nature, the rights of nature (AKA Earth jurisprudence) is a global social movement to provide legal rights for all species of Earth's biosphere, including bodies of water, to protect ecological integrity and thus global life support (Chiji et al., 2019; Borràs, 2016; Matthews, 2019). The application of the rights of nature in the WEF nexus would provide for greater protection for water quality and biocentrism as opposed to the anthropocentric water exploitation common in nexus management.

Relative the Kern County's nexus and the above transitions discourses, as highlighted by Escobar (2015), is Vandana Shiva's 'from oil to soil' which encourages a shift away from a fossil fuel era where society is based on a "mechanical-industrial paradigm centered on globalized markets" to a people-planet-centered society (Shiva, 2008). This shift includes decarbonization, de-corporatization, re-localization whereby "biodiversity-based organic food and energy systems" operate "on the basis of grassroots democracy" and "the preservation of soils and ecological integrity" (Escobar, 2015; Shiva, 2008). Shiva (2008) states that management of food and energy systems can only be considered sustainable if they facilitate a shift to "decentralized, low-impact economies" that do not introduce risks. Shiva (2008) also highlights that food localization would increase food security and food sovereignty. The WEF nexus under these conditions would be managed for outcomes of environmental quality, human health, and grassroots inclusion in food and energy production methods and policy decision-making as opposed to management based on quantity, supply-and-demand, and export commodity production. California's Healthy Soils Program is positioned to aid the shift from oil to soil. The program provides financial and educational support for farmers and ranch owners to increase soil organic matter in a broader effort to increase carbon sequestration in California's ecosystems (CDFA, 2023). The program is funded by CA's cap and trade program proceeds and provides cash incentives for regenerative agricultural practices such as cover cropping, no-till/reduced-till, mulching, and compost applications (CDFA, 2023). These practices would be beneficial in Kern County's nexus and broader nexus management considering healthy soil (soil rich in soil organic matter) reduces the need for fertilizers, increases water-holding capacity thus reducing water demand, increases carbon sequestration potential while also supporting biodiversity and water filtration and thus ecosystem renewal capacity (Lal, 2013; Shiva, 2008).

Finally, several authors that employ the metabolic rift theory argue that the ecological disorganization being created from capitalism represents green crime. Green crime is rooted to ecotoxicology research, has grown via the support of Marxist analysis, and is accordingly concerned with social structures of power and issues of socio-environmental injustice (Lynch, 2020; Long et al., 2014). Green criminologists investigate cases of ecological destruction and pollution exposure risk (broadly) as crimes being committed by corporations and via corporate-state partnerships (Lynch, 2020; Lynch et al., 2013). Kern County's nexus represents an important case of green crime considering the level of risk for exposure to industrial pollution in water in the areas in proximity to nexus industries. Lynch and colleagues (2013) explain that "human preference for organizing economic production consistent with the objectives of capitalism are an inherent contradiction with the health of the ecological system" and that the "capitalist system of production must be seen as a crime against nature." Thus, a WEF nexus being managed according to the demands of economic growth, as Kern County's is, represents such a crime. The "harms approach" in green criminology seeks to reveal social and physical harms resulting from exposure to environmental pollution, particularly via exposure for extended periods of time (Lynch et al., 2013). This aligns with the pollution exposure risk in the WEF nexus of Kern County.

Considering Kern County's nexus as a smaller subset of many rural areas with similar industries, the rural industrialized nexus represents a case of green crime with global implications for sustainability management. From this view, Kern County's WEF nexus is a small subset of a global scale WEF nexus whose function is contradictory to sustainable development. The theoretical frame of this research revealed important dynamics of green crime in the nexus such as physical evidence that the limits to growth have been exceeded and that the metabolic rift represents ecological disorganization and pollution exposure risk that intensifies with proximity to nexus industries. The embodiment of nexus pollution as evidenced by cancer rates, low births weights, infant mortality, and neurological disorders in Kern County provides preliminary evidence for green crime and a call for more studies on green crime in the industrialized nexus.

2.5 Conclusions

This research served two main purposes. The first purpose was to provide a theoretical framing to fill key gaps in WEF nexus methods for sustainability management. Those gaps include integration of multi-scalar systemic linkages, and incorporate environmental, political economic, and social dimensions to better address sustainability governance issues (Albrecht et al., 2018; Simpson and Jewitt, 2019; Wiegleb and Bruns, 2018). This research conceptualized the WEF nexus as a socio-environmental system while joining the limits to growth with Marx's metabolic rift theory as its theoretical frame to investigate water quality in a rural industrialized WEF nexus. The WEF nexus pollution exposure risk zones represent key areas in Kern County to conduct further research to investigate social dymensions of the WEF nexus important for sustainability management.

Following Lövbrand and colleagues (2015), this WEF nexus case study refrained from adjusting to conventional research agendas to encourage the scientific breakthroughs needed for social change. Hinging the limits to growth with a critical theory such as the metabolic rift provided for exploring quantitative and qualitative aspects of water quality in the industrialized nexus while also providing insights into complex systemic functions as reasons for the unsustainable nature of an economic system based on infinite growth. The theoretical frame also provided a critical lens applicable to the rural WEF nexus that opens the door for further research concerning environmental injustice and green crime as well as transitions discourses needed for social change in the nexus. In this way, the frame provides for praxis in WEF nexus methods and management to transition to a society based on sustainability as opposed to capital accumulation and typical development trajectories towards industrialization (Peet and Thrift, 1989; Bhaskar et al., 2010; Lövbrand et al., 2015). The theoretical frame and the methods used in this paper should be applied to further rural WEF nexus studies to compile data on water quality in the WEF nexus in regions of advanced industrial development. This may provide important contributions to global scale water quality data and the planetary boundary of novel entities.

The second main purpose of this research was to conduct a risk assessment to explore the outcomes of water quality in a localized WEF nexus functioning within the demands of the global economic system and within the ecological limits to capitalist growth. This research has demonstrated the efficacy of the framework and that there is a water pollution crisis in the rural WEF nexus of Kern County, CA. Kern County's WEF nexus provides important insights for "developing" counties and regions that are at the precipice of entering (or expanding further into) the fossil fuel development world of fracking and/or industrial agriculture. While immediate measures should be taken to protect individuals in the nexus industry risk zones (i.e., water filtration, remediation, etc.), which should arguably be paid for by the industries creating the problem, social systemic change is needed to create a shift in society to value water and environmental quality more than capital accumulation. Key discourses and methods for research and management strategies to achieve this shift in the rural WEF nexus are as follows.

1) Utilization of research and management frameworks that hinge the limits to growth (minus its Malthusianism) to a critical theory such as the metabolic rift to explore both quantitative and qualitative dynamics of the WEF nexus as a complex socio-environmental system.
2) Further case studies to create a database of water quality in the rural industrialized WEF nexus. This can provide key data contributions for quantification of the planetary boundary of *novel entities*.
3) Engagement with and management based on sustainability transitions discourses.
4) Undertaking of WEF nexus case studies that explore green crime, environmental injustice, and political-economic power dynamics.

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Chapter 3 Sense of Place and Perceived Impacts in the Rural Industrialized Nexus: Insights for Sustainability Pathways

Abstract

As representative of the water-energy-food nexus, fossil fuel development and industrial agriculture are rural industries that continue to expand and increasingly occur in the same areas. Being a top agricultural export county and the fossil fuel capital of California while ranking among the worst in the US for industrial pollution, Kern County is a poster child of rural nexus development and, thus, an essential place for initiating sustainability transitions. Such transitions rely on policy support and the adoption of methods by individuals and communities who may disagree with such changes. While sense of place and impact perceptions are recognized as playing critical roles in sustainability management, they have yet to be utilized in nexus research. A survey (N = 256) of the perceived impacts of nexus industries with place meaning and place attachment as possible drivers for perceptions was conducted in nexus industry pollution exposure risk zones. Factor analysis and bivariate correlations showed that place meaning and place attachment are drivers for perceptions while also being drivers for concern for changes in nexus industries. While perceptions of impacts indicated contested place meanings, participants strongly perceive the economy and environment as being in decline. To build support for sustainability policy, directing funds from Kern County's renewable energy industry to local sectors of society, implementation of regenerative agriculture, cooperative management, and nurturing place meaning as aligned with nature's restorative quality are important paths forward. These nexus management foci could strengthen place attachment, build trust in government, and repair environmental alienation.

3.1 Introduction

While the water-energy-food (WEF) nexus has been adopted broadly for sustainability management, foci of its use and application as an analytical tool have been largely based on resource security to meet the demands of population and economic growth (Albrecht et al., 2018; Wiegleb and Bruns, 2018; Artioloi et al., 2017). These predominant goals and methods have stymied the needed focus on drivers of global change as part of WEF nexus processes, environmental injustice, and local livelihoods, among others (Liu et al., 2018; Albrecht et al., 2018; Biggs et al., 2015; Allouche et al., 2019). A growing consensus among sustainability scholars is that the natural sciences have dominated WEF nexus discourses and that, to align policy with sustainability needs, social scientific approaches need to be promoted (Allouche et al., 2019; Wiegleb and Bruns, 2018). Accordingly, social science approaches provide for the ability to address issues of inequity, environmental justice, and systemic power as well as incorporate local knowledge, culture, and experience of management outcomes in science and policy (Wiegleb and Bruns, 2018; Allouche et al., 2019; Haggerty et al., 2019). Further, decisions about policies that affect socio-environmental management can be improved by incorporating local perceptions and values, the understanding of which comes largely from social science approaches (Mulvaney et al., 2020; Craik, 1973; Adger, 2006; Dietz et al., 2005).

Across the social sciences, sense of place (SoP) has gained recognition as playing a pivotal role in sustainability management and transitions. However, it has yet to be utilized in WEF nexus research and management. As a social theory, SoP provides explanations and insights into human connections to and meanings of a place (Mulvaney et al., 2020). Tuan (1975) explains that “place is a center of meaning constructed by experience.” Accordingly, SoP has been identified as being a critical construct undergirding values and actions, thus possibly providing an essential mechanism for sustainability management of complex socio-environmental systems (Milligan, 1998; Chapin III et al., 2012; Chapin III and Knapp, 2015; Stedman, 2016). For example, social constructs of sense of place represent meaning-making, or cognitive processes that often undergird place attachment, the latter of which has been attributed to conservation behavior (Lee, 2011; Kyle and Chick, 2007). Stedman (2016) suggests SoP, being systematically distributed through society via meaning-making processes, can provide a crucial mechanism for complex socio-ecological systems research and management to escape a theoretical rigidity trap that causes a tendency to overlook personal experience, human cognition of environmental problems, experience of issues, and local perspectives.

The utilization of SoP in sustainability-related research in the separate components of the rural industrialized WEF nexus provides evidence of its value. For example, Davenport and Anderson (2005) investigated SoP and perceptions of landscape change as related to the economic development of the Niobrara National Scenic River. They found river meanings as part of SoP undergirds place attachment, which can shape attitudes and behaviors about planning and management (Davenport and Anderson, 2005). Mulvaney and colleagues (2020) call for researchers to use SoP as a “cultural ecosystem indicator,” considering that measuring the social value of water quality provides a pivotal link to biophysical indicators of water quality important for water quality restoration. Meanwhile, Jacquet and Stedman (2013) explore SoP as a driver for the perceptions of the impacts of wind energy versus fossil fuel development projects, underscoring the importance of perceptions in supporting or opposing such development projects in the face of climate change. Eaton and colleagues (2019) identify rural working landscapes as essential locations for conservation and advise using SoP as an empirical measure to capture the interdependent relations between the “social, economic, and environmental well-being experienced by farmers.” They explain that understanding how SoP “operates” in rural working landscapes can provide needed insight into motivation factors for conservation practices (Eaton et al., 2019).

To promote social science approaches and successful sustainability management outcomes, this research explores place meaning, place attachment, and perceived impacts in the rural industrialized nexus. While the perceived impacts of industry remain an underexplored aspect of WEF nexus research and management, SoP and its role in perceptions of industrial development impacts has yet to be a focus in WEF nexus research and management. Meanwhile, perception of the impacts of industrialization and SoP has been found to be essential for sustainability management policy support. As development continues to follow the path towards industrialization and global demand for food and energy security continues to rely on fossil fuel development and industrial agriculture, understanding SoP and its role in impact perceptions will be important for sustainability transitions in the WEF nexus. This research thus seeks to ascertain the nature of place attachment, place meaning, and perceived impacts of industrialization, as well as correlations between SoP dimensions and perceived impacts in the rural industrialized WEF nexus. The research questions here are (1) What are the socio-environmental impacts, positive or negative, of rural WEF nexus industries perceived by residents, particularly as these industries intersect with water, and in what ways do aspects of place attachment and place meaning represent drivers of perception? (2) How might SoP in the WEF nexus be utilized to better achieve sustainability management and transition policy support? (3) How does the above differ between industrial agriculture and fossil fuel development?

This research centralizes on the rural-industrialized WEF nexus for key reasons. As representative of the WEF nexus, fossil fuel development and industrial agriculture are rural industries that increasingly occur in the same areas and continue to expand (Measham et al., 2016; Rockström et al., 2014). Meanwhile, the demands for energy and food within the broader market rationale of the global economic system are contradictory to ecological limits to this industrial growth, making the rural WEF nexus an essential focal point for sustainability transitions (Meadows et al., 1992; Vargas et al., 2023). For example, while industrial agriculture has been found to be a major driver of global change crises and trajectories towards planetary boundary exceedance, coupled economic-population growth trends provide for projections of 10^9 hectares of natural ecosystems to be converted to industrial agricultural lands by 2050 (Tilman et al., 2001; Campbell et al., 2017). This conversion is expected to be accompanied by a 2.4 – 2.7-fold increase in nitrogen and phosphorus-driven eutrophication and a similar increase in the use of pesticides (Tilman et al., 2001). Meanwhile, the continued reliance on fossil fuels for energy security and a multitude of other industries/products has been supported by a rapid expansion in unconventional oil and natural gas development (hydraulic fracking) (Black et al., 2021). While this expansion has provided income security, it has also led to the degradation of environmental quality and human health while also contributing to the climate crisis (Mayer, 2017; Black et al., 2021). Moreover, Industrial agriculture and unconventional oil and gas development are notorious for water consumption and contributions of chemicals to local water resources (Shrestha et al., 2017; Khan and Hanjra, 2009; Chittick and Srebotnjak, 2017). While sustainability transitions for agriculture and energy production have been prescribed (i.e., decarbonization, regenerative agriculture), such transitions rely on policy support and the adoption of sustainability management methods by communities who may disagree with such changes (Escobar, 2015; Shiva, 2008; Lamine, 2011).

3.1.1 Place Attachment, Place Meaning, and Perceived Impacts

SoP, as a complex construct, comprises feelings, beliefs, meanings, symbols, and values developed through interactions and experiences of people within a setting (Chapin et al., 2012). Classical development of SoP within human geography explored the sense of belonging as associated with sentiments tied to a setting and place, meanings and feelings associated with nurturing, stability, or interpretations of events or experiences, as well as values associated with family, culture, public institutions, and government policy (Tuan, 1975). Tuan (1975) philosophized that the development of SoP depends on time, considering interactions with, involvement in, and experiences of a place take time to accrue. Building from these foundations, place attachment and place meaning are often identified as two key concepts of SoP, with place attachment being dependent on place meaning (Brehm et al., 2013). For example, Stedman (2008) explained that place attachment is a function of place meanings, which are made up of cognitions and personal or shared beliefs, yet that place meaning alone may be more relevant to environmental managers, considering conflicting views on management often stem from place meanings. Meanwhile, place attachment may be a driver of concern for environmental change

(Jacquet and Stedman, 2013). It is thus valuable to explore place attachment and place meaning together to gain a holistic picture of SoP.

Place meanings are cognitive and descriptive elements of attitudes about spatial settings (Brehm et al., 2013). Place meanings evolve through the experiences of an individual and the creation of memories (Quinn et al., 2018). Physical, experiential, and socially constructed aspects of a place are thus central to place meanings (Stedman, 2003). The lived experience provides for the development of place meanings (Tuan, 1975). Common meanings of a place among a group of people represent place meaning as being community, culturally, and economically relevant, which may shape attitudes and behaviors towards the environment (Davenport and Anderson, 2005). Relatively, Cresswell (2008) noted that while sense of place as meanings, individual and shared, are associated with a place, temporal changes in sense of place are rooted in political economic dynamics of certain times and warned that “the sound of the beating heart of sense of place is getting lost behind corporate development.” Alternately, Stedman (2002) highlights that humans are willing to fight for places more central to their identities and perceived as being in less-than-optimal conditions. Thus, research must deal with perceptions, meanings, and beliefs people attribute to and have about a spatial setting (Davenport and Anderson, 2006; Stedman, 2002; Jenkins, 2011).

Place attachment represents the strength of a connection or bond between an individual or group of people with a place which can be emotional, biological, cultural, familial, and/or economic (Stedman, 2008; Brown et al., 2015; Hernández et al., 2007; Cross et al., 2011). Relatedly, two main dimensions of place attachment are place identity and place dependence. Proshansky (1978) defines place identity as “those dimensions of self that define the individual’s personal identity in relation to the physical environment by means of complex patterns of conscious and unconscious ideas, feelings, values, goals, preferences, skills, and behavior tendencies relevant to a specific environment.” Place dependence stems from relationships with a place and beliefs that a place satisfies psychological and/or physical needs (Davenport and Anderson, 2005). While the strength of place attachment is most often correlated with length of residence, place meaning and identity also play important roles in the strength of people-place ties (Hernández et al., 2007). For example, social capital of community, family, and culture provide for emotional ties and personal identity, all of which have relations to places, attachment to those places, and concern for negative environmental change (Giuliani, 2003; Brehm at al., 2013). Giuliani (2003) and others point out that conflicts in places can arise when there are disagreements between groups who have strong attachments to the same place while having different perceptions and values associated with place-based management (Chapin and Knapp, 2015; Jenkins, 2018).

Clearly, place meaning and place attachment play important roles in human perception of a place, which is why SoP is often used in conjunction with perceived impacts in sustainability management research. For example, Davenport and Anderson (2005) ask, “What happens to sense of place when places change?” and “What happens when landscape change threatens place meanings and emotions?” They found that some residents opposed commercial development on the local river due to perceived threats to place meanings (identity, nature, tonic) associated with the river. However, some viewed the development as positive due to river meanings associated with economic stability (Davenport and Anderson, 2005). These differences in perceptions can be attributed to how people consider impacts, positive or negative, in terms of costs and benefits (Quinn et al., 2018). Jacquet and Stedman, (2013) highlight perceptions of impacts as “better predictors of community change and subsequent behavior than measures of the impacts themselves." These points and those above reinforce why SoP may provide essential avenues for helping to address sustainability needs and making actionable WEF nexus research and management.

3.2 Study site

Kern County, located in the southernmost portion of California's San Joaquin Valley (SJV), bears the cumulative impacts of intense rural industrial development, with industrial agriculture and fossil fuel development being the dominant industries (London et al., 2021). Both industries are of colonial origin and follow a typical historical development trajectory towards industrialization, making Kern County an essential case for WEF nexus and sustainability research. Due to its intense rural industrial development and dependence on the production and export of fossil fuel and agriculture for economic growth, Kern County has been characterized as having a resource curse as well as being a fossil fuel and environmental sacrifice zone (Michieka and Gearhart III, 2018; Chandrasekaran et al., 2021). The interactions of these industries with water within the context of never-ending economic growth provide a bleak outlook for sustainability. What is more, being a Mediterranean climate, water resources of the county are quickly diminishing due to the demands of these industries, each of which is notorious for unsustainable water consumption, as well as urbanization, population influx, and the impacts of climate change (Almaliki et al., 2022; Keenan and Krannich, 1997).

Industrial agriculture and fossil fuel development have deep roots in Kern County. Branded as the engine of the US due to its role in growing the domestic roots of the industry, fossil fuel production for profit in Kern County began in the 1860s (Trout et al., 2018). By 1923, the Midway-Sunset oil field produced a quarter of the global oil supply. It remains one of the top production sites in the US and is the largest oil field in California. Known as California's fossil fuel capital, Kern County produces about 367,000 barrels of oil per day, provides 70% and 18% of the state's oil and natural gas, respectively, and is the second largest fossil fuel producer by county in the lower 48 and third in the US providing 5% of US and 1% of global crude oil supply (Thuot, 2014; Mernit, 2019). The historical development of Kern County's agricultural industry mirrors the development of its fossil fuel industry. Fed by colonial-era immigration, agricultural development in the county began during the period of the gold rush, as mining and ranching were the ambitions of colonial pioneers and development tycoons (Jelinek, 1999; Arax and Wartzman, 2003; Turner, 1981). Rancheros and small farms of the County and the broader San Joaquin Valley became the food supply for mining communities until congressional actions led to broadscale privatization of lands, the concentration of land ownership, and the development of industrial agriculture as we know it today (Jelinek, 1999). While Kern County is now a top agricultural producer in the US, with crops exported to 96 countries, it produces the most lucrative crops (i.e., almonds, dairy, grapes, and pistachios) in California (CDFA, 2022). Kern County's agricultural lands receive more than 20 million pounds of pesticides each year, contributing to severe environmental pollution and exposure risk (CA DPR, 2021). Risks include cancer and neurological diseases, among others (Balazs et al., 2012; Rabinowitz et al., 2015; Willin et al., 2020).

Kern County is a poster child of rural WEF nexus development and, thus, an essential place for initiating sustainability transitions. For example, while Kern County is ranked as one of the worst in the US for environmental pollution and has been designated as a disadvantaged community of

California due to pollution burden and water inequity, it also ranks in the top 75th percentile among California counties for tap water toxicity closely linked fossil fuel and agricultural industry pollution (OEHHA, 2019; London et al., 2021; Huang and London, 2012; Balazs et al., 2012). A case in point is Kern County's ranking in the top 68th percentile for 1,2,3-trichlorpropane (TCP) concentrations in California's tap water, with some census tracts ranking in the top 90th percentile for this carcinogen (OEHHA, 2019). 1,2,3-TCP, made by Shell Oil and Dow Chemical, was an ingredient in soil fumigants used in agriculture in California from the 1950s-1980s (Burow et al., 2019; Hauptman and Naughton, 2021). Now outlawed, several counties and other organizations are suing Shell and Dow Chemical for the presence of this dangerous carcinogen in local water resources (Burow et al., 2019; Hauptman and Naughton, 2021). While peak oil is forecasted to be by 2030 and California aims to be carbon neutral by 2045, the county and state continue to approve new oil and gas development permits (IEA, 2023; GOPR, 2023; Consumer Watchdog, 2023). 35% of the county's population lives within one mile of an oil or gas well, with nearly half considered vulnerable populations (Rotkin-Ellman, 2014). These at-risk communities, especially those working in agriculture, are shouldering the burden due to possible exposure to air pollution, pesticides, and drinking water contamination (Rotkin-Ellman, 2014; Perkins and Sze, 2011). Cancer is the second leading cause of death in Kern County, and asthma rates are twice that of the state (Constantine and Jonah, 2017; CDC, 2020).

3.3 Methods

The methods of this research draw heavily from Jacquet and Stedman (2013), who investigated the perceived impacts of wind vs. fossil fuel development projects in addition to place meaning and place attachment as drivers for the perception of impacts. Citing the expansion of energy development projects in rural areas of the US, Jacquet and Stedman (2013) note the importance of understanding why and how residents perceive negative vs positive impacts considering the need to shift towards renewable energy. A primary research objective was to compare perceptions of social, economic, and environmental impacts between the two energy industries, considering the development of each industry may increasingly be in proximity to each other. For example, while research has shown that residents perceive industrial-scale energy development projects as positive for the economy, with social and environmental impacts as negative, other research has shown that residents generally view the environmental impacts of energy development projects as being less important than economic and social concerns (Thompson and Blevins, 1983; Jacquet and Stedman, 2013). Other findings suggest that while perceptions of negative social impacts include decreases in community connectivity and loss of trust in industrial and environmental regulators, environmental impacts include wildlife habitat destruction, loss of access to environmental amenities, and aesthetic disturbances (Mayer, 2016; Anderson and Theodori, 2009). These place values are important considering they may provide roadblocks to gaining support for environmental protection measures if such measures are viewed as being a threat to the economy.

3.3.1 Survey sample and design

The survey was designed to gauge the perceived impacts of the WEF nexus industries of fossil fuel development and industrial agriculture, place meaning and place attachment as possible drivers for perceptions, and comparison of the perceived impacts between the two industries (Jacquet and Stedman, 2013). Duplicate Likert-scale survey questions about industrial agriculture and fossil fuel development impacts were created based on environmental, community, personal, and economic impact constructs. These constructs represent the WEF nexus as a socio-environmental system inclusive of the economy and community as well as the scale of the individual. For each of the 21 variables, the survey asked respondents how each industry has impacted certain aspects of the region where they live by marking one of five boxes for each variable: "very negative," "negative," "neutral," "positive," "very positive," whereby negative = damaged/gotten worse, positive = improved/gotten better. Place meaning was gauged by asking respondents to what degree they agree (strongly disagree, disagree, neutral, agree, strongly agree) with statements about the environment, community, and sustainability concerns in Kern County. Place attachment was gauged using the same 5-point Likert scale asking respondents to what degree they agree with four statements (I am deeply connected to this place, I would not want to live anywhere else, I stay here for job security, my job is connected to the land) in addition to Boolean residency status questions. Demographic questions were also included in the survey, considering past research that has shown such variables to be drivers of concern for perception of environmental risks (Jacquet and Stedman, 2013). A final question on the survey was open-ended and asked residents to provide any additional information they felt should be addressed regarding the impacts of the fossil fuel industry and/or industrial agriculture on Kern County's water.

Surveys were mailed to residents of Kern County in areas with high concentrations of oil and gas development wells and industrial agriculture (Figure 3.1). Survey distribution areas were delineated using a distance-based approach to mapping pollution exposure risk (Mennis, 2002; Mennis and Heckert, 2018; Haggerty et al., 2019). Research has shown that drinking water wells located < 1 km from oil and gas development activities are likely to become contaminated and that individuals living within 2 km of oil and gas development wells may experience adverse health impacts from exposure to related chemicals in water (Rabinowitz et al., 2015; Meng 2015; Wollin et al., 2020). Open-source spatial data of California oil and gas development wells were imported into ArcGIS Pro (V 3.1.0) (CA Department of Conservation, 2023). Buffer analysis was used to create a risk buffer of 2 km around active and idle wells. The dissolve tool was used to merge buffers that overlapped to create fossil fuel development risk buffer zones. Research has shown that, due to soil properties, the valley portion of Kern County has a high probability of pesticide contamination in groundwater (Teso et al., 1996). California's Department of Pesticide Regulation open-source GIS data was used to create a risk buffer of 0.1 km around Kern County agricultural lands that receive the highest applications of pesticides (APC, 2019; CA DPR, 2021). The overlapping buffer boundaries were dissolved to create an industrial agriculture risk zone. A previous study (Weeks, 2023) validated the risk zones by comparing WEF nexus industry-related chemicals in tap water inside, between, and outside of the risk zones. Results showed that, while several chemicals related to WEF nexus industries throughout the valley portion of the county far exceed public health goal safety thresholds, levels were significantly higher within the risk zones and even greater in areas where risk zones overlap (Table 3-1).

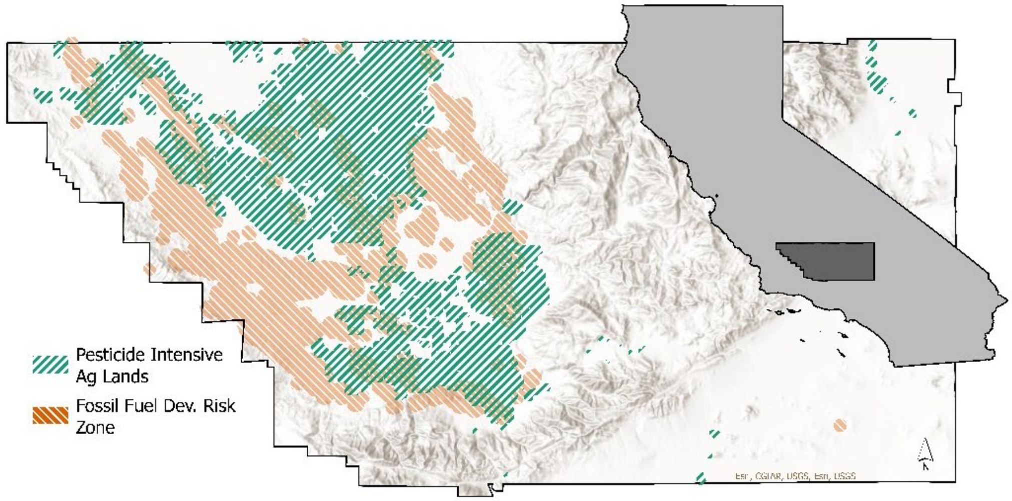

Figure 3.1: Map shows the regions of nexus industry pollution exposure risk of Kern County where surveys were distributed. The survey distribution areas were delineated using a distance-based approach to mapping pollution exposure risk. Map by author.

Table 3-1: Table shows the average levels of nexus industry-related chemicals in Kern County's tap water for each risk zone, outside of the risk zones, and the California's public health goal safety thresholds for each chemical (Weeks, 2021).

Chemical	Average level in tap water - industrial agriculture risk Zone	Average level in tap water - fossil fuel development risk zone	Average level in tap water - combination risk zone	Average level in tap water - outside of risk zones	CA public health goal safety threshold
TTHMs (ppb)	4.4	27.3	12.9	7.2	.015
HAA9 (ppb)	2.4	27.9	4.9	0	.06
Chromium-6 (ppb)	4.17	.64	1.02	0	.02
1,2,3-TCP (ppb)	.014	.0003	.038	0	.0007
DBCP (ppb)	.01	.00003	.004	0	.0017
Arsenic (ppb)	3.7	1.38	8.8	4.08	.004
Nitrate (ppm)	5	1.9	2.3	1.2	.14

USPS Every Door Direct Mail (EDDM) was used for the anonymous distribution of and response to the survey. Mail routes entirely within the risk zones were chosen for survey distribution. Each survey contained a pre-paid USPS business reply mail envelope for survey responses to be sent to a USPS P.O. Box. Surveys were sent to a wide variety of zip codes to decrease bias in the event of a low response rate, with an equal number of surveys sent to the fossil fuel and industrial agriculture risk zones to obtain a representative proportion of responses from populations working or residing near those industries. Further, two versions of the survey (English and Spanish) were sent to the agricultural areas considering the percentage of the population in those areas that are non-English speaking farm working communities. Two thousand five hundred surveys were sent with a response rate of 10.2% (246 English and 10 Spanish surveys returned). The response rate was much higher for the fossil fuel industry risk zone (16%) versus the industrial agriculture risk zone (4%). Even with the more significant response rate from the fossil fuel development risk zone, 18% of the respondents were agricultural workers, while 13% worked in the fossil fuel industry. The survey sample provided answers from all categories of demographics from Kern County. Most respondents were white (69.8%), followed by Latinx (16.5%), Native American (9.4%), Asian/Asian American (2.7%), and African American (1.2%). 58.8% of the respondents were female and 35.7% were male. Limitations of the survey include the low response rate from Latinx communities, considering they represent about 50% of the county, and the low response rate.

3.4 Analysis and results

While the analysis is primarily quantitative, as shown below, qualitative analysis of the open-ended question on the survey was used to identify themes, which were utilized for complementary insights into the perceived impacts, place meaning, and place attachment. Likert-scale survey data were imported into SPSS (V. 29.0). Factor analysis, descriptive statistics, and bivariate analyses were used to evaluate the survey responses (N = 256). While factor analysis was used to examine perceived impact groupings per industry compared to the original survey categories, descriptive statistics were used to gauge perceived impacts, place attachment, and place meaning. Bivariate regression was used to test correlations between SoP variables and perceived impacts to obtain insights into place meaning and place attachment as drivers for perceived impacts (Jacquet and Stedman, 2013). The reliability of the questionnaire was confirmed by calculating the Cronbach's alpha for each category of questions with perceived impacts survey items scoring 0.96, place meaning items scoring 0.84, and place attachment items scoring 0.741. The open-ended survey responses (N = 100) were imported into NVIVO (V. 14.23.2). Auto-coded themes were agriculture, air, fossil fuel, industry, oil, quality, and water. Comments related to these themes provided complementary insights into place meaning and place attachment as related to the perceptions of the impacts of WEF nexus industries as those industries intersect with the environment, the community, the economy, and the individuals taking part in the survey.

3.4.1 Perceived impacts

Factor analysis was used to examine the perceived impacts responses for each industry. This provided for the isolation of constructs and concepts by regrouping variables into variable cluster sets referred to as "factors" while also providing for comparison of the factor constructs with the questionnaire categories (Yong and Pearce, 2013). The factor analysis used principal components extraction based on Eigenvalues greater than 1 with varimax rotation for each industry (Jacquet and Stedman, 2013). The Keiser-Meier-Olkin measure for sampling adequacy was .921 for industrial agriculture and .918 for fossil fuel development, while Bartlett's test of sphericity provided a significance (P-value) of $< .001$ for the survey items for each industry, thus indicating the data's adequacy for factor analysis and that the variables were statistically significant (Yong and Pearce, 2013; Shrestha, 2021). The factor analysis for each industry provided similar outcomes with factor constructs mirroring the questionnaire categories. For example, while there were two resulting factors for the perceived impacts of industrial agriculture, there were three factors for the fossil fuel industry. The two factors for the perceived impacts of industrial agriculture loaded as per "environmental and personal impacts" and "social and economic impacts." The three factors for the perceived impacts of the fossil fuel industry loaded as per "environmental and personal impacts," "community impacts," and "economic impacts."

Descriptive statistics (Table 3.2) show that, while participants were somewhat neutral in their perceptions of the impacts of both industries for many variables, residents had strong perceptions of impacts, negative and positive, for key variables. Industrial agriculture was perceived as having the most significant negative impacts.

Table 3-2: Percentages of the perceived impacts of industrial agriculture vs fossil fuel development in pollution exposure risk zones of Kern County, CA. Likert scale questions asked how nexus industries have imposed environmental, personal, community, and economic impacts by marking one of five boxes for each variable: "very negative," "negative," "neutral," "positive," "very positive," whereby negative = damaged/gotten worse, positive = improved/gotten better

Impacts	Industrial Agriculture		Fossil Fuel Development	
	negative	positive	negative	positive
Environmental				
water quality	39.7	15.8	38.6	19.1
Tap water quality	**46.3**	20.8	40.6	21.1
air quality	**62.3**	12.9	**53.3**	16.5
wildlife habitat	36.2	26.8	38.1	22.8
Access to water	25.6	34.1	27	27.8
Scenic beauty	28.3	36.4	36.6	23.7
Personal Impacts				
Resident health	39.3	23.8	39.9	22.4
Pollution exposure risk	**55.7**	41.8	**52.7**	43.2
Quality of life	30.9	**58.5**	35.3	31.6
Community Impacts				
Trust in local government	**51.8**	12.5	**52.3**	8.7
Community connectivity	32.9	25.6	35.3	21.5
Pride in community	28.7	35.2	31.2	30.8
Inclusion in planning	39.7	15.4	41.1	15.3
Economic Impacts				
Property values	31.8	30.1	34.9	29.9
Job market	32.9	34.5	34.6	35
Economic health	38.9	29.1	35.2	32.8

Environmental Impacts

While the environmental impacts from WEF nexus industries were generally perceived as negative, slightly more so for industrial agriculture than fossil fuel, some impacts were perceived as positive. Air and water quality was perceived as being negatively impacted by both industries but more by industrial agriculture (industrial agriculture 62.3%, fossil fuel development 53.3%). Water quality was perceived as being negatively impacted but less so than air quality. This may be attributed to a lack of awareness of water pollution versus the ability to see and feel the effects, such as allergies or asthma, of air pollution on a regular basis. While perceptions of the impacts of industrial agriculture on scenic beauty were more positive (36.4) than negative (28.3), the perception of the impacts of fossil fuel development for that variable were more negative (36.6) than positive (23.7). It is important to note the percentage of neutral responses for the perceptions of environmental impacts which were generally 30% for half of these variables.

Personal Impacts

The perceptions of personal impacts were among the least neutral variables, with responses showing a sharp divide in perceptions. For example, while both industries were perceived as having negative impacts on pollution exposure risk, slightly more so for industrial agriculture (55.7%) than fossil fuel (52.7%), nearly an equal percentage of participants perceived WEF nexus industries as having a positive impact on pollution exposure risk. Meanwhile, quality of life was perceived as being positively impacted by industrial agriculture (58.5%), with perceptions being slightly more negative than positive for fossil fuel development for that variable. In consideration that 50% of the population of Kern County are Latinx, a comparison of responses regarding environmental and personal impacts perceived by these survey participants versus the rest of the participants could provide insights into potential environmental justice burdens. Results were similar between the two populations except for a 4% increase for pollution exposure risk from industrial agriculture for Latinx survey participants.

Community and Economic Impacts

The perceptions of community and economic impacts were mixed. Trust in local government was strongly perceived as being negatively impacted by both industries but more so by fossil fuel development. Similarly, participants perceived inclusion in planning as being negatively impacted by both industries, slightly more so by fossil fuel development. Alternately, pride in community was perceived as being positively impacted by industrial agriculture while being more negatively impacted than positive for fossil fuel development. Perceptions of the impacts of both industries on the economic variables of property values, job market, and economic health were generally evenly distributed between negative, neutral, and positive. Economic health and property values were perceived as being more negatively impacted than positive.

3.4.2 Sense of Place and Correlations with Perceptions of Impacts

Place meaning – Environment as Restorative

While participants disagreed that Kern County's environment is healthy (60%) and that it is a good place to get away (42%), there was a greater percentage of responses that agreed that Kern County has great outdoor recreation (44.5%) and outstanding natural beauty (45.4) than those who disagreed (25.6% and 22.9% respectively) (Table 3-3). This contradiction may be explained by the perceived positive impact of industrial agriculture on scenic beauty considering aesthetics as part of place meaning (Berleant, 1992). Bivariate correlation analysis between the variables "Kern County has outstanding natural beauty" and the perceived impacts of industrial agriculture variable for scenic beauty was statistically significant (<.001) with a positive Spearman's correlation coefficient (.619), indicating place meaning as related to aesthetics is a driver for the perceived positive impact. Alternately, fossil fuel development was more greatly perceived as having a negative impact on scenic beauty and positively correlated with the place meaning variable of Kern County having outstanding natural beauty. Thus, as fossil fuel development expands, the greater the negative impacts perceived on the aesthetic nature of Kern County.

Table 3-3: Table shows the percentages for survey responses to Likert-scale questions about place meaning.

Place Meaning Categories and Variables	Disagree	Agree
Environment as restorative		
The environment is healthy	**59.9**	19.7
Kern County is a good place to get away	41.5	22.9
Kern County has great outdoor recreation	25.6	44.5
Kern County has outstanding natural beauty	22.9	45.4
Community		
The community is close-knit	29.9	30.7
The community is very friendly	22.1	45.6
Economy		
My job is connected to the land	44.8	25.4
Threatened		
Water quality is in decline	20.1	**53**
The economy is in decline	13.4	**68.8**
I am worried about sustainability in Kern County	13.8	**60.9**

Place meaning – Community

While responses were divided about Kern County's community being close-knit, there were more responses that agreed the community is very friendly (45.6%) than those of who disagreed. (22.1%). While community connectivity is important for community planning and management, other factors outside of this research are most likely having an impact on these variables, such as urban growth and migration of individuals from urban areas to more affordable regions such as Kern County. Community connectivity is discussed further in the following sections.

Place meaning – Economy

While there were two place meaning variables related to the economy, one is in the threatened category and the other in this category sought to ascertain if residents in the WEF nexus industry pollution exposure zones felt their job was connected to the land. While 44.8% of respondents disagreed, 25.4% agreed. There was a significant positive correlation between this place meaning variable and perceptions of the impacts of WEF nexus industries on water quality, air quality, and pollution exposure risk. This means the more individuals see their job as being connected to the land, the greater their perceptions of impacts, which aligns with past SoP research related to this variable (Cross et al., 2011).

Place meaning – Threatened

The "threatened" category of place meaning provided the least neutral responses. Respondents agreed they are worried about sustainability (60.9%) in Kern County and that the economy is in decline (68.8%) while also agreeing that water quality is in decline (53%). Similar to Jacquet and Stedman's (2013) findings, respondents who agreed with variables in the "threatened" category of place meaning had greater perceptions of WEF nexus industry impacts. While there was a significant correlation (<.001) between the place meaning variable of the declining economy and the perceived impacts of industrial agriculture on water quality, there was not for fossil fuel development. Further, the Spearman's correlation coefficient for perceived impacts of industrial agriculture on water quality with the economy being in decline was -.217, thus indicating a negative relationship between the variables.

The open-ended question at the end of the survey provided more profound insights into place meaning in Kern County's WEF nexus, complementary to the above findings, while also showing a deep divide in place meanings related to WEF nexus industries. For example, comments related to the auto-coded theme of industry showed that, while many respondents view Kern County as being WEF nexus industries (i.e., "Kern County is fossil fuel and industrial agriculture"), others view WEF nexus industries as turning Kern County into an export economy that is destroying the environment ("the almond industry takes our water and ships its products overseas"). This shows that industrial development is an important driver of place meaning and a source of contested place meanings. Many comments by respondents reinforced the correlation between their disagreement with the variable "the environment is healthy" and the perceptions of WEF nexus industry impacts on the environment and human health. For example, many respondents commented on the negative impacts of both industries on air and water quality while associating those impacts with their personal experiences of degraded qualities of the environment ("As a resident of Oildale I have to avoid the outside air" "We are a top producer of agriculture in the nation yet we have the worst air quality and health conditions" "The air quality here is horrible because I step out in the morning to that awful stench of gasoline toxins" "Rural areas around Kern County are often discarded regarding water quality and agricultural practices").

Place attachment

The median for the place attachment Likert scale survey items responses (3.0) indicates that place attachment is weak among the respondents (Table 4). While respondents agreed most (43.5%) with the statement "I am deeply connected to this place," they disagreed more (58.1%) with the statement "I would not want to live anywhere else." Furthermore, 44.3% disagreed that their job is connected to the land. This is an interesting outcome, considering that 31% of the survey participants work in fossil fuel development or agriculture. Bivariate correlation analysis indicates that place attachment may be an important basis, or driver, for perceptions of the impacts of industrial development. For example, recall that responses indicated greater perceptions of the negative impacts of industrial agriculture on water quality than fossil fuel development. The correlation between the variable "I am deeply connected to this place" and the perceived impacts of WEF nexus industries in water quality was statistically significant (<.001) for each industry but stronger for industrial agriculture (r = .311** for fossil fuel and .375** for industrial agriculture). Further, while the correlations between place attachment variables and perceived impacts of WEF nexus industries on environmental quality were statistically significant, the correlations were positive, thus indicating that as place attachment increases, so do the perceptions of impacts. Relative are insights that can be drawn from residency status as related to related to place attachment. Whereas lifetime residency and place attachment were weakly correlated (r = .189**), the correlation between year-round residency and place attachment was not statistically significant (P = .544). While this backs SoP research that has shown that place attachment develops over time, lifetime residents being 50% of survey respondents should have resulted in greater agreement with place attachment survey variables. This discrepancy may be related to place meaning or place attachment becoming subsumed into industrial development, which is considered in the discussion section.

Table 3-4: Table shows the percentages of survey responses to the Likert-scale questionnaire items on place attachment.

Place attachment	Disagreed	Agreed
I am deeply connected to this place	29	43.5

I would not want to live anywhere else	58.1	18
I stay here for job security	35.3	30.2
My job is connected to the land	44.3	25.1

Like place meaning, survey responses to the final open-ended survey question provided complementary insights into place attachment. For example, the auto-coded industry theme provided more profound insights into place connection whereby WEF nexus industries are experienced as an integral part of the local social system, providing multi-faceted stability to local livelihoods. Responses show this to be especially true for the fossil fuel industry as participants highlighted its important contributions to the economy, schools, community outreach, and police. This is an important finding because proposed changes to that basis for stability, such as decarbonization, may be viewed as a threat. Exemplary comments include, "the oil industry provides quality, decent paying jobs in this community that wouldn't exist without the oil industry," "Kern County prospers from the oil industry through land taxes and permit fees that help pay for police and schools." Examples of this dynamic were also present in participant comments about the need to deregulate the fossil fuel industry, such as the "fossil fuel industry lacks jobs because of state regulation" and "open up the oil industry so people can get back to work." There were also clear concerns for the closure of the fossil fuel industry in comments such as, "leave the oil industry alone" and "The fossil fuel industry is an important part of Kern County and should not be shut down."

3.5 Discussion

This research found that aspects of place meaning and place attachment are drivers of perception of the impacts of WEF nexus industries as shown with similar research on SoP (Jacquet and Stedman, 2013), though it also found that aspects of place meaning and place attachment are drivers of concern for changes in the local industry. This discussion focuses on the latter first, then explores the former in consideration of ways to increase sustainability management and transitions policy support in the WEF nexus. Two key findings of this research were that WEF nexus industries have shaped place meaning for Kern County residents and that place attachment is rooted to these industries, particularly fossil fuel, as livelihoods through monetary support for local institutions such as schools and police are supported. Place meaning and attachment being formed over time through personal and social experience as well as livelihood stability provided by WEF nexus industries thus undergirds the drive for concern for changes. This is not a surprising finding considering the length of time these industries have been part of the fabric of Kern County's socio-environmental system. However, it is an important finding for sustainability management policy support in the WEF nexus.

As theorized by Tuan (1975), place meaning develops through lived experiences. However, what about dominant constructs of place meaning and attachment – those of community, culture, and political-economic relevance? Stedman (2016) briefly dives into the problem of systemic power influencing the construction of place meaning, pointing to the works of Foucault (2009) and Gramsci (1971), who explain that institutional and systemic power influences the normalcy of meanings, behavior, and even common sense. This line of thought related to SoP has been explored deeply by David Harvey (1993; 2018), who, using Marx's theory of alienation, explains how universal alienation materializes as capital accumulation becomes the goal of life under the current political-economic ontology. Harvey (1993) quotes Relph (1976), who warned that place is being rendered placeless by “organizational power and depth of penetration of the market” in the logic of individuals. Similarly, Bell and York (2010) exemplify the treadmill of production as being reinforced by the manipulation of place attachment by the coal industry who constructed an ideology of dependency and economic identity. These insights may explain the weak strength of place attachment demonstrated by survey participants and the general neutrality for more than half of the perceived impacts variables, even in the face of severe environmental degradation in Kern County. These findings present a deeper problem that needs to be addressed at the personal level of the WEF nexus as a system – to strengthen place attachment and build upon aspects of place meaning to cultivate support for sustainability transition policies such as decarbonization and regenerative agriculture.

Confronted with alienation, how might SoP in Kern County’s WEF nexus be utilized, improved, or recovered to achieve sustainability management? One pathway may be provided by focusing on the restorative quality of nature as a factor of place meaning considering this research found it to be an important driver for perceptions of the negative impacts of WEF nexus industries. Drawing from Stedman (2002), who explained that humans are willing to fight for places that are more central to their identities and perceive as being in less-than-optimal conditions, nurturing place identity and meaning aligned with a healthy environment would be an important path forward. In recognition of this need, some promote SoP as a cultural ecosystem service to develop place meanings and connections, personal and social systemic, between humans and local ecosystems. For example, personal and group involvement in ecosystem restoration activities has been shown to build place connection and identity, thus nurturing support for conservation policy (Lokhorst et al., 2014; Hausmann et al., 2015). There are seemingly endless opportunities for ecosystem restoration in the heavily industrialized ecosystems of Kern County. Rivers have often been the focal point for such activities (Quinn et al., 2019), as well as the development of small-scale agriculture as a win-win discourse of conservation based on place meaning and place attachment (Masterson et al., 2019).

There was a statistically significant association between the variable “the economy is in decline” of the threatened category of place meaning and the environment/restorative category variable “Kern County has outstanding natural beauty” thus backing this line of thought and proposed action. It would be advantageous then to provide avenues to demonstrate and build upon the restorative nature of the environment as integral to the WEF nexus and, thus, the long-term sustainability of the economy. For example, 44% of respondents agree that Kern County has outstanding natural beauty and great outdoor recreation, thus indicating these aspects of place meaning may be point of pride. Past research has shown that pride in a place as one that highly values its ecosystems can strengthen place attachment (Marshall et al., 2019). Relatively, while survey participants perceived industrial agriculture as having a positive impact on scenic beauty, they perceived that industry as having the most negative impacts on the environment and pollution exposure risk. Place meaning related to the beauty of agriculture and place-based pride could be enhanced by transitioning to agricultural practices that build ecosystem resilience.

The threatened category of place meaning survey items were most agreed with among all SoP survey variables, with nearly 70% viewing Kern County’s economy as being in decline and 60% being worried about sustainability. There needs to be a greater effort to assure Kern County residents that sustainability transitions in the WEF nexus, such as decarbonization and regenerative agriculture, will greatly benefit the community and economy instead of being a threat. Relative to the perception of threat to the economy, responses showed that residents perceive WEF nexus industries as having a negative impact on trust in the government. This critical finding indicates a need for greater grass-roots involvement in planning and decision-making processes (Armitage et al., 2007). For example, Johnson and Rickard (2022) found that seeing community change as positive was increased using a cooperative management approach. In terms of the fossil fuel industry, just transitions are needed to ensure that renewable energy jobs pay as well (or better) as those of the fossil fuel industry and that those working in fossil fuel get training and job security during the transition (Healy and Barry, 2017). Moreover, considering place attachment was found to be a driver of concern for threats to the fossil fuel industry due to monetary support (land taxes and permit fees) for social institutions from that industry, support for Kern's social systems needs to be enhanced from its renewable energy sector which generates far more renewable energy than any other county in California (Zhang et al., 2022).

Finally, this research found conflicting views about the impacts of WEF nexus industries, thus representing contested visions of sustainability in Kern County's WEF nexus. Chapin III and Knapp (2015) suggest that "stewardship is best fostered by transparent and respectful dialogue to identify shared values and concerns and negotiate areas of disagreement." Providing arenas (workshops, community forums, planning meetings) for such activities in Kern County could provide opportunities for discourse among residents to increase awareness of shared concerns for sustainability transitions, environmental pollution related to WEF nexus industries, and shared values related to place meaning and place attachment such as those found in this research. Further, this research found that the survey participants disagree the community is close-knit, which could be shifted through such venues for dialogue. Such venues could also build social networks and ultimately strengthen place attachment.

3.6 Conclusion

This research demonstrates the importance of social science and the relevance of SoP in WEF nexus research and management. Rooting WEF nexus research to the local social dimension as bound to the broader socio-environmental system provided important insights into local perceptions as well as place meaning and place attachment as drivers for perceived impacts and concerns for community change. An important finding of Kern's WEF nexus is that, due to long-term industrialization, WEF nexus industries have shaped place meaning and that WEF nexus industries, particularly fossil fuel, are experienced as being an integral part of the local social system providing multi-faceted stability to local livelihoods. Place meaning and attachment are formed over time through personal and social experience, as well as livelihood stability provided by nexus industries, which are drivers for concern for changes in WEF nexus industries. These concerns need to be relieved and trust in government and policy built, which can be achieved via cooperative management and arenas for sharing knowledge and concerns. Just transitions are needed also to alleviate concerns for community change. Weak place attachment and related alienation, or placelessness, is an important outcome in the rural industrialized WEF nexus that needs tending and mending to increase support for sustainability transitions, particularly for decarbonization. Nurturing place identity and meaning as being aligned with a healthy environment provides an important path forward, which can be aided through personal and group activities to build pride in healthy ecosystems in Kern County areas impacted by WEF nexus industries.

Critical actions for aligning constructs of SoP with sustainability management in the rural industrialized WEF nexus materialized from this research. To gain support for sustainability policy and transitions, the environment as being restorative as a key factor of place meaning needs to be developed. A key avenue to do this is through ecosystem restoration projects that involve the community and individuals. These projects should include river restoration, the implementation of small-scale and regenerative agriculture, and the remediation of fossil fuel development areas. In addition to making environmental amenities a greater aspect of the economy, these activities will alleviate the threatened factor of place meaning. Cooperative management and increased monetary support for local sectors of the community (schools, police) from the renewable energy sector are also needed. Cooperative management will provide arenas for discourse between individuals with contested visions of sustainability and building trust for government and policy. These WEF nexus management foci will also help to strengthen place attachment and repair environmental alienation.

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Chapter 4 Exploring Green Crime and Rationalization in the Rural Industrialized Water-Energy-Food Nexus and Considerations for Sustainable Development Goal 6

Abstract

While the water-energy-food nexus has become a commonly used model for assessing systemic synergies and trade-offs for sustainable development goals, severe gaps in nexus research and political-economic rationale undergirding definitions of development continue to undermine the objectives. To promote critical social science approaches and successful sustainability management, this research contributes a mixed methods case study of the water-energy-food nexus in a rural region in the advanced stages of industrial development, Kern County, California, using green criminology as the theoretical lens. A county-wide spatial analysis of nexus industry-related chemicals in tap water was conducted using open-source water quality data and California's public health goal safety thresholds. Qualitative survey responses (N = 100) and critical thematic analysis were used to explore the personal experiences and political-economic influence on the rationality of individuals living in nexus industry pollution exposure risk zones. Results show that Kern County's water-energy-food nexus is producing green crime, including ecological disorganization, victimization, and unequal exchange, and that individual rationality shaped by the broader political-economic system is a driver of the treadmill of production. A redefined version of the sustainable development goals should include a goal of transforming the structure of the economy to match the needs of local socio-environmental communities to ensure pollution is not being produced beyond the capacity of ecosystem renewal to maintain public health goal safety threshold standards for water quality. Radical democratization and cultivation of sustainability ideology are also needed to slow the destruction of the treadmill in the rural water-energy-food nexus.

4.1 Introduction

In a special (2023) report, the United Nations (UN) raised the alarm about the need for increased action to attain the 17 Sustainable Development Goals (SDGs) by 2030. While the water-energy-food (WEF) nexus has become a commonly used model applied to the SDGs and sustainability management, systemic contradictions continue to undermine goals (Simpson and Jewitt, 2019; Botai et al., 2021; Malagó et al., 2021; Ioannou and Laspidou, 2023). For example, in a (2022) technical brief, the UN acknowledged water, energy, and food as key societal sectors having positive and negative implications for attaining the SDGs. These implications include strategic synergies to support success across a variety of goals but also trade-offs that may contribute to uneven development and, thus, outcomes contrary to the SDGs (United Nations, 2022). While the UN's (2023) special report for the SDGs warns that targets are moderately or severely off track and that a fundamental shift is needed to put the world on a better path towards sustainability, others critique the SDGs and WEF nexus research and management framings for being based on economic growth imperatives which are contrary to the ecological limits to growth, the planetary boundaries, and contribute to environmental injustice (Adelman, 2018; Allouche et al., 2015; Middleton et al., 2015; Meadows et al., 1972; 1992; Rockström et al., 2009).

As part of a Pathways to Sustainability book series, Allouche and colleagues (2019) provide essential foci for WEF nexus research while highlighting that governing the nexus "is probably one of the grand challenges of the 21st century." The book highlights the influence of politics and power in shaping nexus research and management to be based on scarcity (supply and demand) and the crucial need to prioritize social and environmental justice (Allouche et al., 2019). While core perspectives of nexus research and management have been guided by economic rationality, it is that same rationality that has shaped the inequitable structures of society, global change crises, and the materialization of a dire need for the SDGs (Hoff, 2011; Allouche et al., 2019; Allouche et al., 2015). We cannot expect to achieve sustainability using the same rationale that has caused the crises of the Anthropocene (Adelman, 2018; Angus, 2016; Foster et al., 2010; Klein, 2007). Thus, "there is a need for critical social science analysis and conceptualization of the nexus" (Allouche et al., 2019). Several critical and systematic reviews have merged on similar deficiencies. Among those deficiencies include methodological foci based on resource security while largely overlooking the localized outcomes of economic growth imperatives and industrial development (Albrecht et al., 2018; Wiegleb and Bruns, 2018; Artioloi et al., 2017). To fill these critical gaps, nexus research should include case studies of environmental degradation as part of nexus processes, the use of social science and mixed methods approaches, critical political economy, and environmental justice framings (Wiegleb and Bruns, 2018; Albrecht et al., 2018; Allouche et al., 2019; Simpson and Jewitt, 2019).

In response to the compounding multi-scalar socio-environmental impacts of industrialization and limitations of commonly used approaches to research and management, the critical social science approach of green criminology has grown in popularity for sustainability studies. However, it has yet to be utilized in WEF nexus research and management. Green criminology seeks to reveal the economic origins of environmental destruction as crimes against nature and those exposed to environmental pollution, thus making it an essential contribution to WEF nexus research and management and the SDGs. For example, in a critique of the SDGs, Bloustein and colleagues (2018) highlight the problematic nature of "development" being rooted in colonial and neoliberal rationality with a goal of modernization, which has shaped inequitable structures of society, uneven development, severe ecological degradation, and environmental justice issues, all of which are contrary to sustainability management and the SDGs. They explain that green criminology can supplement other forms of knowledge in sustainability management by building evidence of the unsustainable nature of development based on infinite capital accumulation and by bringing local experiences of injustice into policy (Bloustein et al., 2018).

4.1.1 Theoretical Positions of Green Criminology

Born from environmental sociology, green criminology uses an interdisciplinary approach to investigate environmental degradation and related socio-environmental harms stemming from capitalist industrial development, thus aligning with the complexity of the WEF nexus and the SDGs (Lynch et al., 2017; Bloustein et al., 2018). Moreover, critical political economy is central to the approach to conceptualize the structural inequality built into the economic system of the current political-economic paradigm, thus filling critical gaps in WEF nexus research methods and conceptualization (Schnaiberg, 1980; Clark et al., 2022; Lynch et al., 2019; Bloustein et al., 2018; Simpson and Jewitt, 2019; Wiegleb and Bruns, 2018). For example, two main theories are used in green criminology – Marx's metabolic rift theory and the treadmill of production. Marx's metabolic rift theory was born from concern for sustainability during the industrial revolution (Foster, 1999). The theory explains that capitalism relies on a social structure of inequality whereby exploitation of the working class and the environment provides for the accumulation of wealth by those in power (Lynch et al., 2017). To ensure capital accumulation continues indefinitely, increasingly intensive labor, mechanization, use of chemicals, and environmental exploitation is required (Schnaiberg, 1980; Clark et al., 2022; Lynch et al., 2017). This process produces external costs (negative externalities), such as social inequity, environmental pollution and related health impacts (Foster, 1999; Lynch et al., 2017).

Similalrly, the treadmill of production is a theoretical model that considers production and consumption as mechanisms for capital accumulation (Schnaiberg, 1980; Gould et al., 2008). The treadmill is driven by the political economic demand for infinite capital accumulation, resulting in contradictions to socio-environmental sustainability due to finite natural resources and pollution sink limitations (Schnaiberg, 1980). Both the metabolic rift and the treadmill of production explain that the socio-environmental contradictions of capitalism result in ecological disorganization (Schnaiberg, 1980). As related to the rural industrialized WEF nexus, Lynch and colleagues (2017) explain that industrial agriculture produces ecological disorganization in the form of chemical additions, which intensify over time due to the requirement for increased productivity under capitalism. Accordingly, these theories are used in green crime case studies whereby green crime is defined as "an act that causes or has the potential to cause significant harm to ecological systems and humans for the purpose of increasing or supporting the accumulation of wealth" (Lynch et al., 2017; Lynch et al., 2013).

4.1.2 Research Significance and Objectives

To promote critical social science approaches and successful sustainability management, this research contributes a mixed methods case study of a rural industrialized WEF nexus using a green criminology lens. Ravitch and Carl (2016) note that case studies are useful when the researcher seeks to understand an issue or problem using a case as an illustration while also providing the ability to investigate mechanisms for and societal underpinnings of unsustainability. Albrecht and colleagues (2018) identified various benefits of using mixed methods approaches in WEF nexus research and management. Those include facilitating interdisciplinarity, estimating impacts, and providing thresholds to inform decision-making, stakeholder engagement, and critical analysis of combined qualitative and quantitative data. Lynch and colleagues (2017) explain that case studies can be instrumental in addressing problems of society as they serve as examples and can be collected as multiple cases to build evidence for needed change.

This case study centralizes on a rural WEF nexus of an advanced developed region for key reasons. As representative of the WEF nexus, industrial agriculture and fossil fuel development are rural industries that increasingly occur in the same areas and continue to expand (Measham et al., 2016; Rockström et al., 2014). Meanwhile, the demands for energy and food within the broader market rationale of the global economic system are contradictory to ecological limits to this industrial growth, making the rural WEF nexus an essential focal point for green criminology research as well as the SDGs (Meadows et al., 1992; Vargas et al., 2023). Finally, while WEF nexus research and focus areas of the SDGs are commonly those of the global south and underdeveloped regions, the outcomes of industrial development in advanced industrialized areas remain less studied. Case studies of the outcomes of industrial development can provide critical lessons for less developed regions and the SDGs.

4.1.3 Study Site

This green criminology case study takes place in the southernmost county of the San Joaquin Valley, which has undergone intense rural industrial development – Kern County, CA (Figure 4.1). With fossil fuel development and industrial agriculture being its primary industries, Kern County is an essential location for a green crime case study of the WEF nexus relevant also for the SDGs. For example, While Kern County is branded as being the engine of the US due to its role in growing the domestic roots of the fossil fuel industry, it is recognized as being the fossil fuel capital of California (Cooke, 2014; Thuot, 2014; Mernit, 2019). From the late 1800s, fossil fuel pipelines originating in Kern County's oil fields spread outward to connect a significant network of fossil fuel transport headed by the Southern Pacific Railroad for transportation for "crude energy" and the building of an oil-based energy system in Southern California (Cooke, 2014). Kern County produces about 367,000 barrels of oil/day, provides 70% and 18% of the state's oil and natural gas, respectively, and is the second largest fossil fuel producer by county in the lower 48 and third in the US, providing 5% of US and 1% of global crude oil supply (Thuot, 2014; Mernit, 2019). Kern County is thus an important hub for the persistence of an economic system based on fossil fuel, which is contrary to a variety of SDGs, including goals 6 (clean water and sanitation), 7 (affordable and clean energy), 11 (sustainable cities and communities), and 13 (climate action) (Malm, 2016; United Nations, 2023; Cooke, 2014).

Figure 4.1: Map shows the location of Kern County within California. Map by Author.

In recognition of the complex nature of the WEF nexus as a socio-environmental system grappling with sustainability management, this case study uses a mixed methods approach. Using mixed methods has several advantages over using quantitative or qualitative methods alone. For example, social theory and qualitative data provide complementary explanations for quantitative data and causal relationships (Creswell, 2009). Further, merging quantitative and qualitative approaches and data enhances the validity of case study findings (Creswell, 2009; Yin, 2013). This research uses quantitative water quality data and qualitative survey responses to broadly ascertain if green crime is occurring in the WEF nexus of Kern County and how political-economic structures shaping social and environmental outcomes and rationalization.

4.2 Methods

In recognition of the complex nature of the WEF nexus as a socio-environmental system grappling with sustainability management, this case study uses a mixed methods approach. Using mixed methods has several advantages over using quantitative or qualitative methods alone. For example, social theory and qualitative data provide complementary explanations for quantitative

data and causal relationships (Creswell, 2009). Further, merging quantitative and qualitative approaches and data enhances the validity of case study findings (Creswell, 2009; Yin, 2013). This research uses quantitative water quality data and qualitative survey responses to broadly ascertain if green crime is occurring in the WEF nexus of Kern County and how political-economic structures may be shaping socio-environmental outcomes and rationalization. Methods specifics for the quantitative and qualitative approaches are explained below. The quantitative and qualitative data analysis results are triangulated with the theoretical positions of green criminology to answer the broad research question. The discussion section considers the implications of the results for SDG-6.

4.2.1 Quantitative data and analysis

The quantitative section of this research investigates if green crime is occurring due to nexus The quantitative section of this research investigates if green crime is occurring due to nexus industry-related chemical additions to local water resources. This is done by assessing 1) if levels of nexus industry-related chemicals in tap water have exceeded public health goal safety thresholds and 2) if the levels increase with proximity to nexus industries. Lynch and colleagues (2017) explain that social and environmental harms of industrial development need to be quantifiable and that scientific standards, as opposed to criminal law, should be used for green crime investigations. This is because criminal law "is created by, and for the benefit of, the powerful so that their behaviors remain relatively unchecked while the behaviors of the working class are controlled to their further benefit" (Lynch et al., 2017). Accordingly, California's public health goal (PHG) contaminant level limit for each chemical was used as a threshold for analysis. California's PHG safety thresholds for chemicals in tap water are based on scientific research that includes health risk assessments to identify the threshold level for a chemical to not cause adverse health impacts for a person who would drink that source of water for 70 years (OEHHA, 2024). For cancer-causing chemicals, a one-in-a-million risk threshold level is determined whereby "not more than one person in a population of one million people drinking water daily for 70 years would be expected to develop cancer" (OEHHA, 2024).

A county-wide GIS analysis of nexus industry-related chemicals in tap water was conducted. A literature review of environmental toxicology case studies and the Environmental Working Group's (EWG) tap water quality database was used to identify chemicals of interest. Table 4-1 includes the chemicals investigated in this case study related to fossil fuel development and industrial agriculture and their possible health impacts. A database containing the levels of each chemical in tap water per zip code throughout Kern County (EWG, 2021) was created. The database was imported into ArcGIS Pro for spatial characterization. Chemical levels were symbolized using California's Office of Environmental Health Hazard Assessment PHGs for each chemical as the baseline in a manual interval classification scale.

Table 4-1: Chemicals in Kern County's tap water that have linkages to fossil fuel development and/or industrial agriculture, health risks associated with these chemicals, and California's public health goal safety thresholds. Sources: Balazs et al., 2012; Rabinowitz et al., 2015; Wollin et al., 2020; Waller et al., 1998; 2020; EWG, 2021.

Chemical	WEF Nexus industry relation of chemical	Health risks of chemical	PHG safety threshold
Total Trihalomethanes (TTHMs)	Fossil fuel development	Liver, kidney, and intestinal tumors. Carcinogen. Pregnancy: Spontaneous miscarriage, cardiovascular and neural tube defects, low birth weight.	0.15 ppb

Haloacetic acids (HAA9)	Fossil fuel development	Pregnancy - Genotoxic (induces mutations). Carcinogen	0.06 ppb
Chromium-6	fossil fuel development and industrial agriculture	Carcinogen. Neurotoxin.	0.02 ppb
Arsenic	Industrial agriculture and fossil fuel development	Carcinogen: Bladder, lung, and skin cancer	0.004 ppb
1,2,3-Trichloropropane (1,2,3-TCP)	Industrial agriculture	Carcinogen	.0007 ppb
1,2-Dibromo-3-chloropropane (DBCP)	Industrial agriculture	Male sterility and testicular damage. Carcinogen	.003 ppb

To ascertain if nexus industry-related tap water pollutants increased with increasing proximity to nexus industries, the distance-based approach of buffer analysis to delineate nexus industry-related water pollution exposure risk (Figure 4.2) (Mennis and Heckert, 2018; Mennis, 2000; Meng, 2015). Environmental toxicology case studies informed buffer distances for nexus industries. For example, research has shown that drinking water wells located < 1 km from oil and gas development activities are likely to become contaminated and that individuals living within 2 km of oil and gas development wells may experience adverse health impacts from exposure to related chemicals in water (Rabinowitz et al., 2015; Meng, 2015; Wollin et al., 2020). Open-source spatial data of oil and gas development wells in California were imported into ArcGIS Pro and used to create a fossil fuel development risk zone (CA Department of Conservation, 2023). Buffer analysis was used to create a risk buffer of 2 km around active and idle wells. The dissolve tool was used to merge buffers that overlapped to create fossil fuel development risk zones. Research has shown that, due to soil properties, the valley portion of Kern County has a high probability of pesticide contamination of groundwater (Teso et al., 1996). Following this, California's Department of Pesticide Regulation open-source spatial data was used to create a risk buffer of 0.1 km around Kern County agricultural lands that receive the highest applications of pesticides (APC, 2019; CA DPR, 2021).

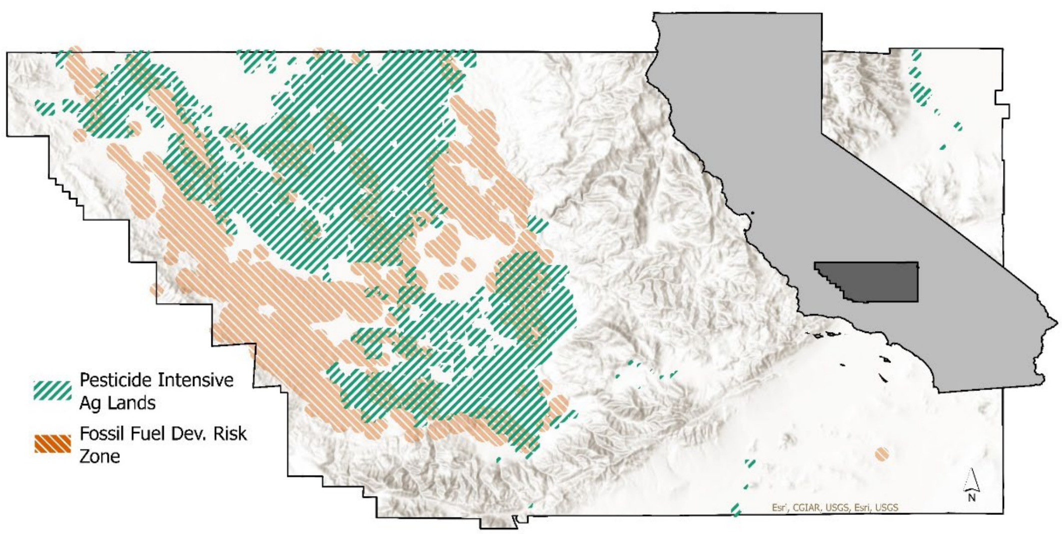

Figure 4.2: WEF nexus water pollution exposure risk zones and survey distribution area. Map by author.

While nexus industry-related chemicals in Kern County's tap water far exceed PHG safety thresholds, chemical levels are higher near their relative nexus industry pollution source, thus indicating green crime. For example, Figure 4.3 shows the levels of 1,2,3-TCP in tap water throughout the county. The highest levels (up to 43x the PHG safety threshold) are in the pesticide-intensive agricultural lands risk zone. 1,2,3-TCP, made by Shell Oil and Dow Chemical, was an ingredient in soil fumigants used in agriculture in California from the 1950s-1980s (Burow et al., 2019; Hauptman and Naughton, 2021). While it is now outlawed in soil fumigants, 1,2,3-TCP is highly stable and does not readily bind to soil, thus providing for its leaching into groundwater resources and being a persistent pollutant (Hauptman and Naughton, 2021; Love, 2019). In their call for the development of a maximum contaminant level to be set by the federal government, Hauptman and Naughton (2021) emphasize the extreme monetary cost of remediation of water contaminated with 1,2,3-TCP as well as the prospective cost to human health being cancer in regions where levels exceed safety guidelines.

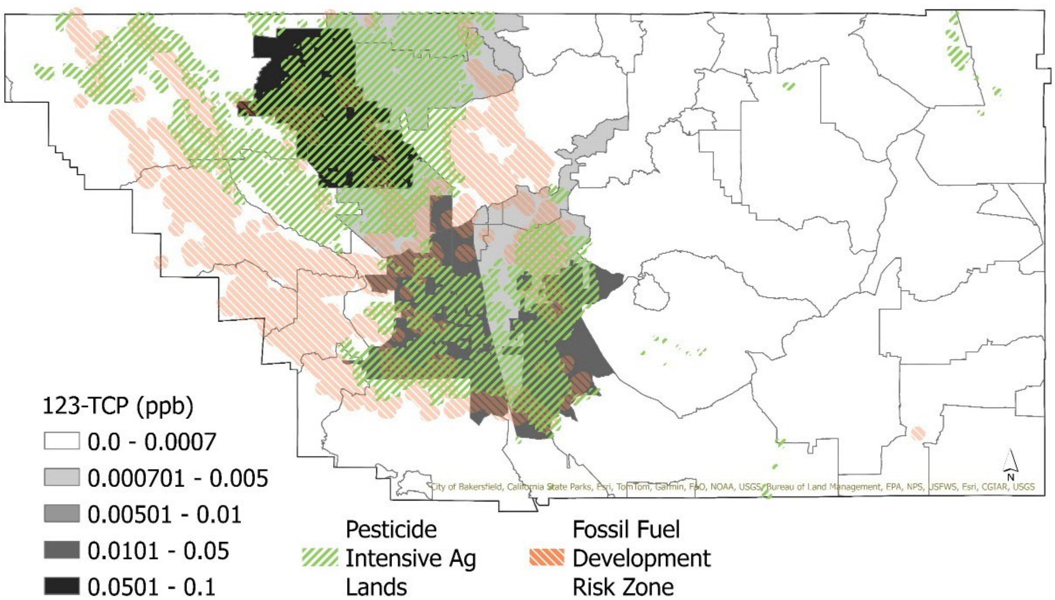

Figure 4.3: Levels of 1,2,3-TCP in tap water per zip code throughout Kern County overlaid with WEF nexus industry water pollution exposure risk zones. Zip code areas that are any shade of grey are areas where levels of 123-TCP in tap water are higher than the public health goal safety threshold of 0.0007 ppb. Darker shades of gray represent higher concentrations.

Now also an outlawed pesticide ingredient, the spatial materialization of DBCP in tap water (Figure 4.4) is similar to 1,2,3-TCP. Levels for this chemical in tap water in the pesticide-intensive-agricultural lands risk zone are more than 8x the PHG safety threshold while being less than the threshold throughout the rest of the county, thus strongly indicating green crime. While DBCP also persists in the environment long after its use, risks to animal and human health include cancer, reductions in male fertility, and testicular damage, among others (Whorton et al., 1979; Hauptman and Naughton, 2021).

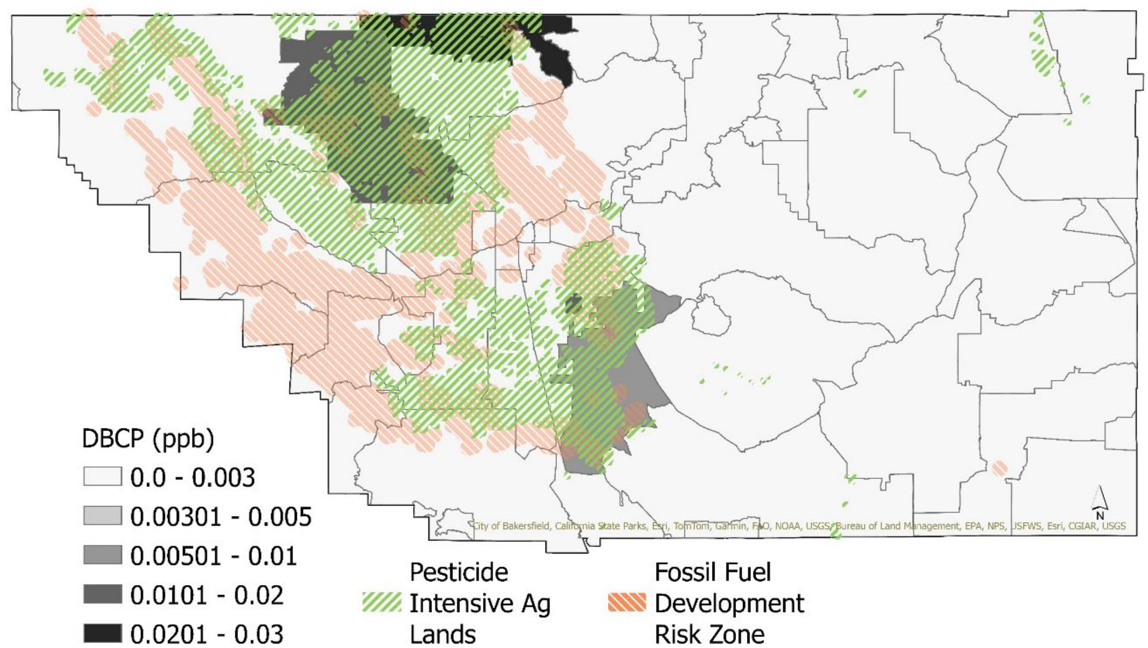

Figure 4.4: Levels of DBCP in tap water per zip code throughout Kern County overlaid with WEF nexus industry water pollution exposure risk zones. Zip code areas that are any shade of grey are areas where levels of DBCP in tap water are higher than the public health goal safety threshold of 0.003 ppb. Darker shades of gray represent higher concentrations.

Chromium-6 levels in tap water were above the PHG threshold throughout most of the county. However, the levels were highest (> 4 ppb) within a portion of the agricultural risk zone, which also overlaps with fossil fuel development (Figure 4.5). Chromium-6 has been associated with fossil fuel development due to its common occurrence in hydraulic fracking wastewater and presence in drinking water resources near fracking sites (Wollin et al., 2020; Brockovich, 2020). For example, legally mandated water quality testing of fracking flowback water in Kern County has shown chromium-6 to be at levels up to 2,700 times higher than the CA PHG safety threshold (CBD, 2015). Meanwhile, research has shown that trivalent chromium, which occurs naturally in the soils of the San Joaquin Valley, transforms into chromium-6 due to interactions between industrial agriculture and certain types of soil (Hausladen et al., 2018; Mills et al., 2011). Chromium-6 has extreme health risks, as exemplified by its classification as a group one carcinogen by the World Health Organization while also being a neurotoxin, immune system suppressant, and the cause of "a variety of chronic, cardiovascular, and neurodegenerative diseases" (Sharma et al., 2022).

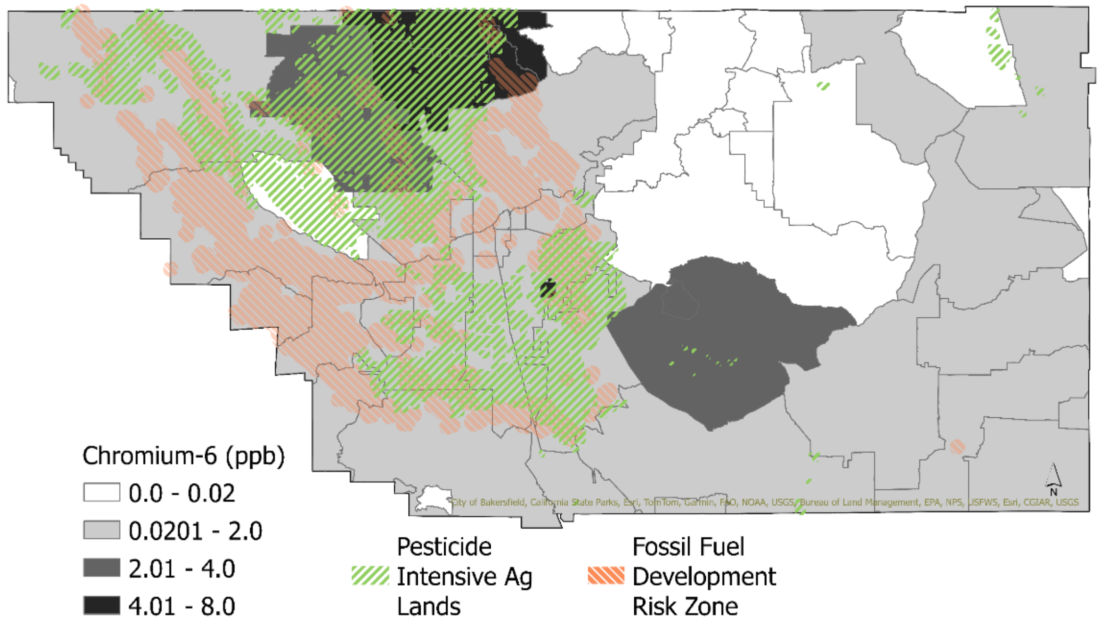

Figure 4.5: Levels of chromium-6 in tap water per zip code throughout Kern County overlaid with WEF nexus industry water pollution exposure risk zones. Zip code areas that are any shade of grey are areas where levels of chromium-6 in tap water are higher than the public health goal safety threshold of 0.02 ppb. Darker shades of gray represent higher concentrations.

Figure 4.6 and 4.7 show that the fossil fuel development-related chemicals in tap water, HAA9 and TTHMs, exceed PHG safety thresholds and are highest where fossil fuel development activities are taking place. While HAA9, the sum mass of nine acetic acids, and TTHMs, volatile organic compounds (VOCs), form as a biproduct of chlorine disinfection of water, the production of these chemicals in public water systems has been correlated with fossil fuel extraction activities and fracking flowback fluids (Fisher et al., 2016; Levin et al., 2023). This correlation is attributed to the presence of bromide, organic chemicals, and VOCs, among other chemicals, in fossil fuel extraction and production wastewater (Zahn et al., 2019; Harkness et al., 2015). Risks associated with HAA9 and TTHMs in tap water include cancer, fetal and DNA mutations, cellular death, spontaneous miscarriage, cardiovascular and neural tube defects, and low birth weight, among others (Wollin et al., 2020; Evans et al., 2019; Levin et al., 2023; Waller et al., 1998; Peterson et al., 2023).

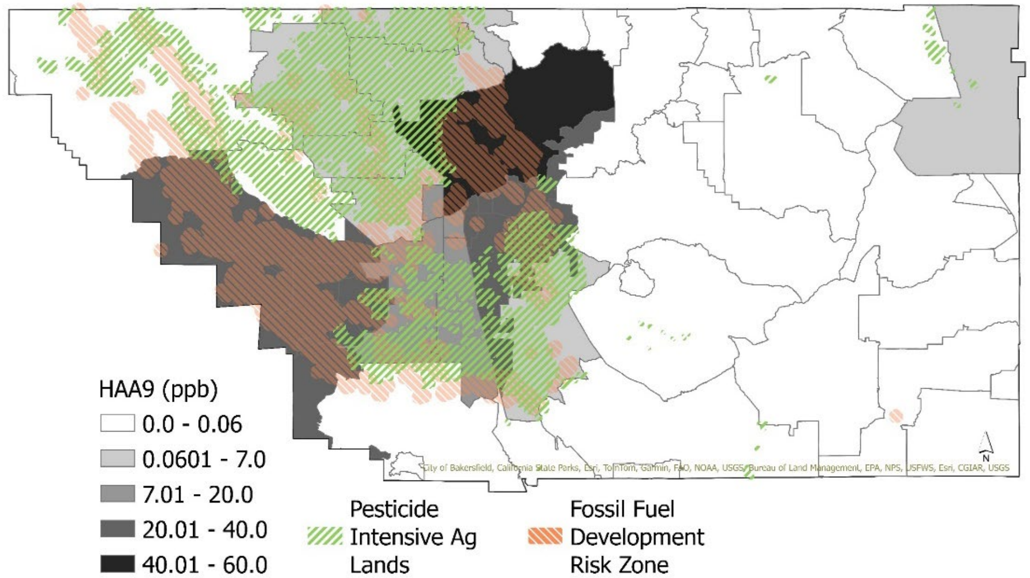

Figure 4.6: Levels of HAA9 in tap water per zip code throughout Kern County overlaid with WEF nexus industry water pollution exposure risk zones. Zip code areas that are any shade of grey are areas where levels of HAA9 in tap water are higher than the public health goal safety threshold of 0.06 ppb. Darker shades of gray represent higher concentrations.

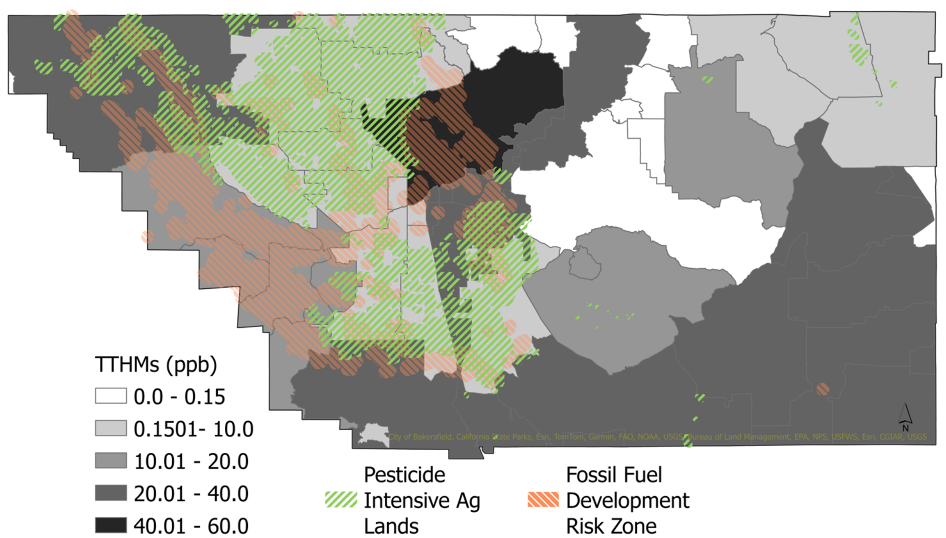

Figure 4.7: Levels of TTHMs in tap water per zip code throughout Kern County overlaid with WEF nexus industry water pollution exposure risk zones. Zip code areas that are any shade of grey are areas where levels of TTHMs in tap water are higher than the public health goal safety threshold of 0.15 ppb. Darker shades of gray represent higher concentrations.

Arsenic levels in tap water were above the PHG safety threshold throughout most of the county, yet it was highest in the southeast area of the valley portion of the county which has overlapping industrial agriculture and fossil fuel development (Figure 4.8). While arsenic is a heavy metal that occurs naturally in the soil, it was historically used in its pure form as a pesticide and is now used as a pesticide in chemical compounds, such as disodium methylarsenate and monosodium methylarsenate (Kun et al., 2014). Because arsenic occurs naturally in the soil, anthropogenic activities such as mining, fossil fuel development, and tillage in agriculture can cause contamination of groundwater and municipal water resources (Balazs et al., 2012; Kun et al., 2014). Being poisonous to multi-cellular life, arsenic is associated with impaired immune function, adverse birth outcomes, metabolic disorders and diabetes, kidney, liver, and neurological disease (Levin et al., 2023; Kun et al., 2014). Moreover, arsenic is recognized as a Group 1 carcinogen by the US Environmental Protection Agency, meaning it is known to cause cancer, as it causes oxidative DNA damage, genomic instability, and "DNA repair inhibition leading to mutagenesis" (Straif et al., 2009; Kun et al., 2014).

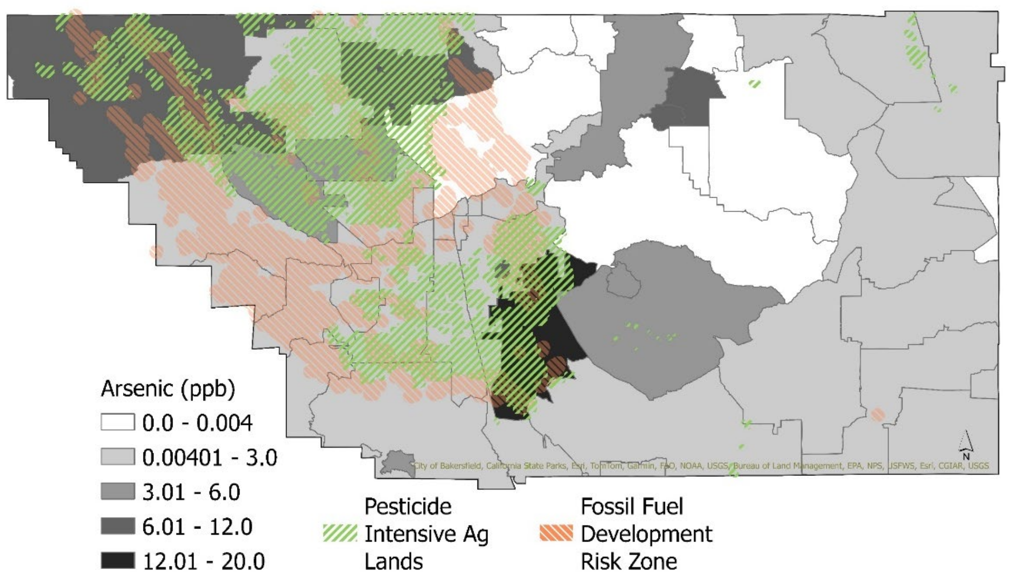

Figure 4.8: Levels of arsenic in tap water per zip code throughout Kern County overlaid with WEF nexus industry water pollution exposure risk zones. Zip code areas that are any shade of grey are areas where levels of arsenic in tap water are higher than the public health goal safety threshold of 0.004 ppb. Darker shades of gray represent higher concentrations.

The results of the quantitative section of this research clearly indicate that green crime is being produced due to the externalities of capitalist industrial development in the rural WEF nexus of Kern County. The risks associated with these externalities also indicate that harms are being imposed not only on the quality of water and the environment but also individuals living in the pollution exposure risk areas of the WEF nexus.

4.2.3 Qualitative Data and Analysis Results

The qualitative data in this case study comes from a survey of place meaning, place attachment, and the perceived personal, social, environmental, and economic impacts of WEF nexus industries in Kern County. The survey was mailed to residential addresses within the WEF nexus pollution exposure risk zones (Figure 4.2). It included a final open-ended survey question that asked participants to provide any additional information or insights on what they felt should be addressed regarding the impacts of the fossil fuel industry or industrial agriculture on Kern County's water (Weeks and Jenkins, 2024). The qualitative survey responses (N = 100) were analyzed using critical thematic analysis to explore the personal experiences and rationality of individuals living in the WEF nexus pollution exposure risk zones (Figure 2). While investigating the personal experiences of survey participants may provide insights into industrial pollution victimization, those experiences may also provide deeper insights into the social outcomes of nexus industry pollution and the political-economic structures of society (Peeples and DeLuca, 2006; White, 2010; Centonze and Manacorda, 2017). Rationality, on the other hand, is an essential dynamic of the nexus as a socio-environmental system, considering it is influenced by economic and ecological constraints as well as cultural and political dynamics and provides the basis for behavior and policy positions on environmental management (Todd and Gigerenzer, 2003; Stoddard et al., 2021; Peet, 1999; Antonio and Bonanno, 2000; Bausch, 1997). Rationality may thus be an important explanatory variable for the political-economic conditions creating green crime while also being essential for combatting green crime (Lynch et al., 2017; Spapens et al., 2014).

Critical thematic analysis (CTA) builds upon Braun and Clarke's reflexive thematic analysis (RTA) which is an interpretative approach to coding and production of a set of themes for analysis of qualitative data (Braun and Clarke, 2019; Byrne, 2022; Lawless and Chen, 2019; Braun et al., 2022). Reflexivity is an essential aspect of RTA, which acknowledges the researcher as a primary instrument in data collection and analysis. Thus, the researcher needs to reflect on their assumptions, values, and actions along the research process to consider personal impositions on the research outcomes while acknowledging that the researcher is not unbiased nor are they seeking neutrality (Braun and Clarke, 2019; Braun et al., 2022). Drawing from critical theory and critical discourse analysis, CTA seeks to reveal issues of power and embedded ideologies by connecting themes "with larger social and cultural practices nested in unequal power relations" (Lawless and Chen, 2019). CTA thus aligns with the theoretical positions and intentions of green criminology, which uses critical political economy to investigate environmental degradation and related socio-environmental harms stemming from capitalist industrial development (Schnaiberg, 1980; Clark et al., 2022; Lynch et al., 2017).

Braun and colleagues (2022) explain that critically oriented RTA uses an interrogative approach to identify meanings and what the implications and effects of the meanings may be. However, the critical orientation as related to theory is vague. While Braun and Clarke (2019) explain that the approach to thematic analysis could apply a mix of inductive and deductive reasoning, their approach has been critiqued for needing more actual reflexivity as well as critical approaches (Lawless and Chen, 2019; Thompson, 2022). Considering this weakness of RTA, Thompson (2022) provided a guide to abductive thematic analysis and explained that abduction "aims to find a middle ground between induction and deduction." Using abduction, existing theory and literature can explain empirical findings, while contributions to theory and theoretical development can also occur (Thompson, 2022). Abductive reasoning is used here as existing theory, literature, and knowledge from the quantitative section of the research is playing a role in theme development and most certainly the final step of analysis of the themes, while contributions to green criminology and WEF nexus case studies, particularly as related to goal 6 of the SDGs, may emerge.

Following from the results of the quantitative section and drawing from green criminology, this section of the case study asks: 1) What are the personal experiences of the survey participants? 2) In what ways are political-economic structures and conditions shaping the rationality of survey participants?

The CTA of the survey responses followed the six phases of RTA (Braun et al., 2022), the steps of which include: 1) data familiarization, 2) coding as relative to the research questions, 3) initial theme generation, 4) reviewing and developing themes that tell a story, 5) refining, defining, and naming themes based on the theme's interpretative story, 6) theoretical analysis in discussion section. NVivo (V 14.23.2) was used to code the survey responses manually. Nine codes materialized, falling into four main themes in step three, with three final refined themes in step five (see Figure 4.9 thematic map). While the theoretical foundations of green criminology aided the formulation of the final themes, one theme materialized from the codes that are not usually associated with green crime, which provided an important tie between the themes – unequal exchange.

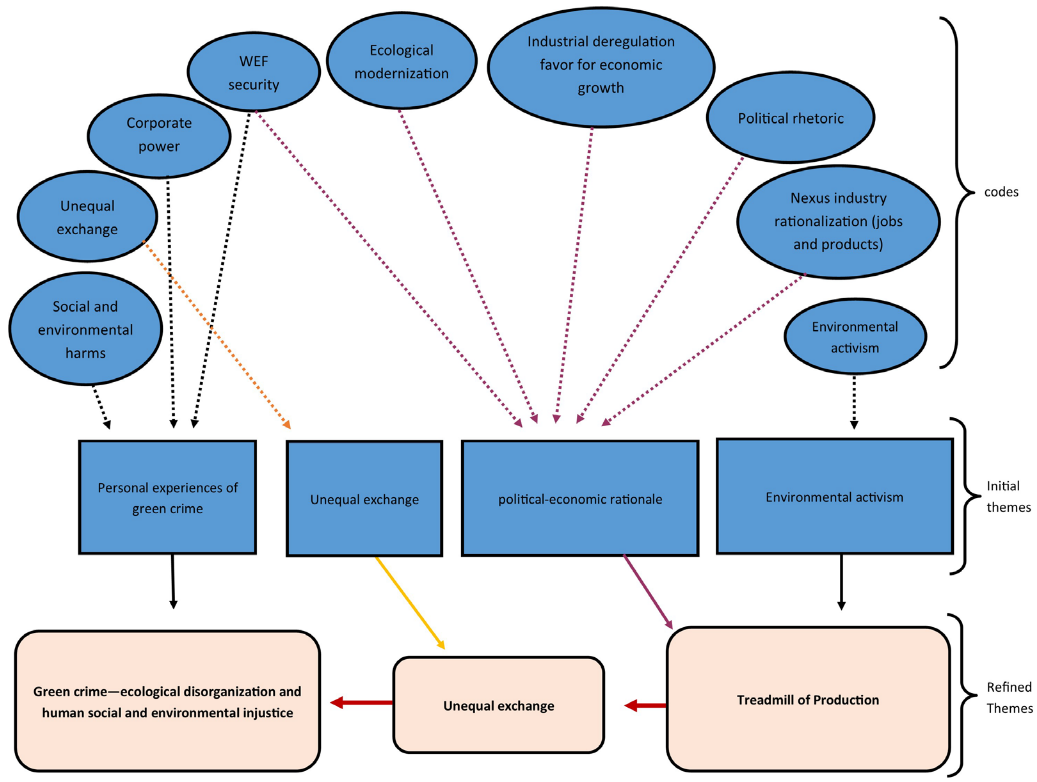

Figure 4.9: Thematic map shows the process and outcomes of the critical thematic analysis. Nine codes fed into the four initial themes which fed into the final three refined themes of the treadmill of production, unequal exchange, and green crime.

Theme 1: Treadmill of production

Five out of nine codes fed into the initial theme of political economic rationale which ultimately fed into the theme of the treadmill of production. Survey responses thus revealed political-economic rationalization as being a driver of the ToP in the WEF nexus of Kern County. This finding provides an explanatory link between the local social system and ecological degradation that receives less attention in green criminology than the role of corporations and the state but very important considering the power of individuals driving collective phenomenon (Liebe and Preisendorfer, 2010). For example, the concept of rational choice often used in criminology positions the individual at the micro-scale within a macro-scale social situation using situational logic to formulate actions (Liebe and Preisendorfer, 2010). Those actions, often based on constraints, aggregate at the macro-scale in collective phenomena (Liebe and Preisendorfer, 2010). As relative to what's driving the treadmill, participant responses that coded to "nexus industry rationalization" exemplify rational choice being based on economic constraints, such as:

> "The oil industry provides quality, decent paying, jobs in this community that wouldn't exist without the oil industry." "The fossil fuel industry is an important part of Kern County and should not be shut down. Many jobs would be lost or curtailed. Do not let Gavin Newsom close down our fossil fuel industry." "Fossil fuel is essential to the economy in Kern County. Many people rely on work in the oil fields. Too many people will be affected if the industry is disrupted or discontinued."

Rationalization can also be influenced by tactics to "manipulate morale and legal norms,' such as greenwashing and "encouragement of ignorance to downplay and deny environmental crimes and harms," the influences of which are defined as secondary green crime (Goyes et al., 2021; Ngamkaiwan, 2023). An example of this is a survey response that stated, "Having worked in the fossil fuel industry for many years, I know personally the oil companies make every effort to protect and defend the natural habitat, endangered species, and even environment. The fossil fuel industry is crucial for Kern County as far as employment for many residents, crucial for our economy, and the sustainability for Kern County and the USA."

Political and economic ideologies appeared to play an important role in the way survey participants rationalized nexus industries. While Schnaiberg (1983) highlights the importance of social supports of the ToP, such as ideologies, others exemplify political rhetoric and economic ideology as key mechanisms that support the ToP which can create an "economy vs the environment" dynamic that shapes attitudes and perceptions (Longo and Baker, 2014). There were several more comments that followed this line of thought to legitimize the industrialized nexus such as:

> "Our biggest obstacle to the health and the economy of Kern County is the left-wing politician who is determined to destroy what makes this country viable." "Tell the Sierra Club and Environmentalists to take a hike. Oil is this country's life blood. If we would open up drilling all over this country, we would tell the foreign oil producers to buzz off. We have more oil in the US than all other countries combined. But the government is keeping the US dependent on foreign oil! It's time for the silent majority to take back our state and government from the politicians."

As part of the political-economic rationale, respondents legitimized the petrochemical industry and fossil fuel development in Kern County by claiming it supports many products in society, including products that are meant to support decarbonization. For example, while one participant stated, "Without the oil provided, we would not be able to produce the many things we enjoy today," others stated, "Wind turbines are made from fossil fuel products," and "Tesla cars are made of 80% fossil fuel products." This rationale as an important mechanism in the ToP is even reflected in participant comments related to the codes "ecological modernization" and "WEF security." Schnaiberg (1983) highlighted the shift in the environmental movement in the 1960s to a technology movement due to concerns for energy security in the 1970s, which resulted in pro-technical solutions and environmental protection complacency. He explained that the "softening" of the environmental movement enables the ToP as technological solutions undergirded by corporate influence and resource security concerns become the goal of development strategies and dominant ideologies (Schnaiberg, 1983). This process represents "satisficing" in rationalization whereby the individual chooses a solution that provides a compromise to the conflict at hand (DeLara et al., 2015; Weston, 2000). Ecological modernization represents satisficing as technological solutions (solar energy, carbon trade, desalinization) to environmental degradation and resource depletion are meant to create an ecologically sustainable capitalism while maintaining the current political-economic structure and treadmill logic (Mol, 2002). Survey participant responses reflecting these ideologies include:

> "If water is a concern in our area, we need to upgrade the water treatment infrastructure with help from the petroleum industries that tap into our waters." "Kern County and California should petition the governor to invest in desalinization and set up a series of pipelines to serve the counties on an as-need basis. The ocean would provide all the water California needs plus enough to sell water to the adjacent states, the money made from which could go to paying for the desalinization and pipelines."

Two codes feeding into the ToP and treadmill of law theme play important roles in a cycle between regulation and deregulation in the treadmill: "environmental activism" and "industrial deregulation favor for economic growth." Schnaiberg (1975; 1980) explains that, as the treadmill produces harmful levels of pollution, a feedback in the system of environmental activism occurs to demand change to protect human and environmental health. While participant responses that were coded as environmental activism were few, they represent an important aspect of the social system that can slow the treadmill of production (Lynch et al., 2018). Examples of the environmental activism feedback in participant comments include, "The agricultural industry needs to use less pesticides. It takes water to grow crops so hopefully we can keep farming here. I'm not in favor of the fossil fuel industry. I believe in climate change. We need farmland, not more fossil fuel." Another participant stated, "We need more campaigning about air quality and to teach children about the issue. Social media would be a good place to spread information about water pollution from industrial agriculture and fossil fuel development."

More recent developments of the ToP have added an additional feedback of deregulation which occurs in response to regulations that impede growth, which is known as the treadmill of law (ToL) (Lynch et al., 2018; Mao et al., 2020) Lynch and colleagues (2020) explain that the ToP and the ToL are interconnected through political economic and corporate power and that the ToL will 'oppose the enhancement of environmental regulation, fail to enforce criminal laws in ways that would alter production practices, and define intense opposition (social movements) to ToP interests as criminal." Environmental and industrial deregulatory activities are also recognized in green criminology as secondary green crime because they enable primary green crime (Goyes et al., 2021). There were several comments from participants that reflect the support of these types of activities, such as:

> "Deregulate both industries. Make it easier for these industries to do business so they can hire more people, pay more money, and create more wealth. Liberals have turned this beautiful state into a shithole. I am so close to relocating my business to another state like so many businesses have already done." "I don't think the government should be allowed to control the industry that has sustained our county for so many years." "It is not a good idea for Governor Newsom to deny permits for oil drilling in Kern County. Drilling for

> oil in our own county and state could go a long way for lowing gas prices." "Drill baby drill."

Theme 2: Unequal exchange

The code that contained the most survey responses was unequal exchange, which, because of its obvious importance, is why it was saved as a final theme. The broad story behind this theme is that Kern County residents in the survey region are experiencing trade-offs that are not serving their interests equally and, in many cases, represent environmental injustice. This theme represents uneven development patterns and external costs that emerge from the treadmill of production (Foster, 1999; Lynch et al., 2017). Several participants communicated their frustration regarding wages vs cost of living vs pollution burden such as:

> "There are a lot of people suffering from low wages and a high cost of living for a place that is so heavily polluted." "Fossil fuel and agriculture have been my two questionable issues here in Kern County. I don't understand why a county that produces a major portion of a natural resource does not share its financial benefits with its communities. We not only do the work but also suffer hazards that are associated with manufacturing and cultivation of these products, yet gas is overpriced and produce costs are becoming ridiculous. If any, we residents of Kern County should be compensated." "Why are local gas prices so high when we live right next to refineries? Why is the produce offered at our local markets so awful? I live in Oildale. Anyone in Kern County should not have this complaint! We should have the best fruit and produce here. We put up with crop dusting. I don't understand why the fruit here has no flavor or it never ripens. If you do get something that looks good, it rots the next day. Food like this should just be fed to pigs, not us people."

This represents what is known in environmental sociology as ecological unequal exchange which is related to critical theories of uneven development such as World Systems Theory and Marx's metabolic rift theory (Wallerstein, 1974; Lynch and Long, 2022). Jorgenson (2016) argues that the theory of (ecological) unequal exchange fills a gap in the ToP by addressing global structural inequality and asymmetrical power relations between more-developed and less-developed regions. As related to green crime, unequal exchange represents the "environmentally damaging withdrawal of energy and other natural resource assets" and "constitutes the obtainment of natural capital and the usurpation of (pollution) sink capacity" (Jorgenson, 2016). As applied in World Systems Theory, unequal exchange occurs between the core (developed) countries and the periphery (developing) countries whereby the periphery gets stuck in an underdeveloped state of poverty a natural resources extraction locations, which parallels the development outcomes in Kern County (Wallerstein, 1974; Lynch et al., 2019). As explained by the metabolic rift theory, rural regions produce food and extract raw materials for urban areas and export to the global economy thus representing ecological unequal exchange of the externalities of capitalism (Foster, 1999; Napoletano et al., 2019). Lynch and colleagues (2019) argue that unequal exchange in the current political economic paradigm represents green crime due to social inequity in uneven development. Participant responses that reflect these aspects of unequal exchange include:

> "Small towns are impacted the most in the case of water and air quality (farmworker residents)" while another stated, ""Rural areas around Kern County are often disregarded (city of Arvin) regarding water quality and agriculture practices (like spraying chemicals

> within city limits).” “The most important thing is the water. I have had to buy drinking water all my life and all of the people are tired of having to buy water all year long in Arvin.”

Theme 3: Green crime

Relative to the findings in the quantitative section of this case study, green criminologists exemplify the outcomes of the ToP being ecological disorganization which represents green crime. For example, “ecological disorganization occurs when humans extract natural resources from an ecosystem and convert them into products through manufacturing, and in the process release toxic wastes” (Stretesky et al., 2013; Lynch et al., 2013; Lynch et al., 2017). As related to Kern County’s WEF nexus, Lynch and colleagues (2013) explain that ecological disorganization produces indirect forms of green crime victimization and exemplify the health harms associated with water pollution. They go on to explain that these harms and cases of victimization often go unaccounted for due to the duration of victimization (Lynch et al., 2013). While survey participants did not express concerns for the health impacts of nexus industry water pollution, they did have comments reflecting other harms being imposed due to nexus industry ecological disorganization. For example, several survey participants wrote about air pollution from nexus industries, particularly the fossil fuel industry, and related health impacts:

> “The only issue about life here is the terrible air quality. I have yet to see any movement on air quality.” “Long term fossil fuel industry will interrupt children's health in the future. Oildale does not consider that our air quality is very low. As a resident of Oildale, I have to avoid the outside air. We can smell gases and burn oil, very frequently, especially morning and night.” “The air quality here is horrible because I step out in the morning to that awful stench of gasoline toxins. I have been awakened a few nights by that horrible smell which has also woken me up early in the morning. As an individual with lung disorders, this is horrible.”

While the comments above represent the external costs of capital accumulation being indirect green crime, there were also experiences of nexus industry expansion destroying communities while also imposing pollution harms. For example:

> “I have lived in the middle of the oil fields for 16 years. I have seen the oil industry destroy my town (Derby Acres). The park has been stripped away piece by piece. Oil steam systems are bled down onto the community, blowing nasty toxins into the air that blows into my home by swamp cooler (smells horrible). Now they are buying up homes and boarding them up. Makes it hard to sell my home,” another stated, “Right now Kern County is filled with the objective to make money, money, money and leave the mess behind.”

4.3 Discussion

This case study revealed that the rural industrialized WEF nexus of Kern County is producing green crime and unequal ecological exchange due to the contradictions of capitalism. The findings of this case study have implications for SDG 6 (clean water and sanitation) which aims to ensure access to “safe” water as a basic human need. Also contradictory to this goal is the acknowledgement by The United Nations that there will be “tradeoffs” in the SDGs because “development *must* balance social, economic, and environmental sustainability” (United Nations, 2024). These statements symbolize the structural inequity and contradictions of the current economic rationale of "development" in the SDGs. Tulloch and Neilson (2014) critique the neoliberal articulation of sustainability using the work of Antonio Gramsci, who explains that the hegemonic economy gains the consensus of the masses via the incorporation of the ideology of subaltern classes and oppositional movements. Including the economy in its current structure and development imperatives as part of the SDGs thus contradicts the goals of equity, protection of the planet, and even peace and prosperity, considering the findings of this case study. Thus, broadly, there is a need to redefine the SDGs to have a goal of transforming the structure of the economy to match the needs of local socio-environmental communities to ensure pollution is not being produced beyond the capacity of ecosystem renewal to maintain threshold standards. Currently, SDG 6 does not include a comprehensive list of industrial chemicals that threaten the goal, nor does it propose *scientific* thresholds for WEF nexus industrial chemicals in drinking water resources (United Nations, 2024). Those of focus in this case study could be incorporated into the goal and others associated with fossil fuel development and pesticide use to provide better progress on the goal.

Considering the WEF nexus is a model adopted for attaining the SDGs, redefining management goals is also needed for the nexus. Allouche and colleagues (2019) explain that the neglect of issues of rights and justice in WEF nexus research has led to the inability to see adverse systemic outcomes of nexus management projects, which are designed to satisfy the demands for infinite economic growth. These adverse outcomes represent the trade-offs the UNEP acknowledges as being an unavoidable, and thus acceptable, aspect of the SDGs. While reducing such trade-offs is a common goal in WEF nexus research for sustainability management, economic sustainability as a common goal trumps social and environmental needs (Bhaduri et al., 2015). Here, we find ourselves trapped in the treadmill of production, even in the realm of management, seeking to escape its destructive path, which is why it is also referred to as a treadmill of destruction (Schnaiberg, 1980; Hooks and Smith, 2004; Clark and Jorgenson, 2012; Givens, 2014). Hooks and Smith (2004) warn that the treadmill cannot be reduced to capitalism alone because it is "driven by a distinct logic of geopolitics." Thus, redefining goals to truly attain sustainability must also take on the enormous task of transforming the logic and rationalization of individuals. More than half of the survey responses in this case study used political-economic rationale to defend and justify the impacts of nexus industries and even call for deregulation to empower treadmill capacity. Much of the rationale was undergirded by seemingly inexorable economic constraints and influenced by political rhetoric (Weston, 2000; Jenkins, 2018). Defining pathways out of the treadmill is clearly very important yet so daunting that many seek the comforts of denial while others choose the satisficing approach, as shown in some of the survey responses of this case study (Weston, 2000; De Lara et al., 2015; Marsden, 2007).

Faced with the problem of the treadmill trap, in what ways can the treadmill be controlled or slowed to attend to issues of ecological destruction and social inequity? Gould and colleagues (2008) explain that because the treadmill functions systemically from the global to local scale, resistance and social movements must strengthen and match those scales. Allouche and colleagues (2019) call for nexus thinking from below, echoing Gould and colleagues (2008) advice that the growing demand for a radical democratization of policymaking is an essential aspect of the work needed. This research revealed the rationalization of many in the rural industrialized nexus to be far from ready to start or participate in a social movement to demand decarbonization or regulatory actions against nexus industry pollution. Following Gould and colleagues' (2008) advice, the cultivation and strengthening of sustainability ideology is needed. Another critical path to slowing the treadmill has already been identified in this research, which is to require that industry does not introduce pollution beyond the capacity of ecosystem renewal based on scientific thresholds for pollution levels in water. This tactic aligns with Schnaiberg's (1980) ecological synthesis method to slow the treadmill. However, his synthesis relied on the "state" to limit "producers' access to the environment based on scientifically determined biophysical limits of what is environmentally sustainable," which is problematic considering corporate power and the influence of economic constraints on decision-making processes, as green criminology explains (Lynch et al., 2017; Schnaiberg, 1980; Lewis, 2018). In recognizing this problem in nexus management for sustainability, Allouche and colleagues (2019) emphasize the need for cooperative management and grassroots inclusion in decision-making to promote just outcomes for the environment and local communities. Finally, two critical tactics for slowing the treadmill of destruction and better achieve SDG 6 include decarbonization and adoption of non-toxic agricultural practices such as organic, biodynamic, and regenerative agriculture. Just transitions and political economic programs, such as the Green New Deal, can support the local social and environmental system in this transition (Barbier, 2009; Ocasio-Cortez, 2019).

4.4 Conclusion

Industrial water pollution is a primary threat to achieving the goals of environmental sustainability and SDG 6. This green criminology case study of the rural industrialized nexus revealed that the status quo for "development" being capitalist industrialization will not lead to prosperity but severe water quality issues, social inequity, and environmental injustice. Allouche and colleagues (2019) explain that "issues of rights and justice have been neglected in debates about the WEF nexus" and that people living in rural areas are especially vulnerable to the outcomes of industrial development. This case study provided a contribution to WEF nexus research that contends with issues of rights and justice while also providing a key example of the vulnerable nature of individuals living in the rural industrialized nexus. The findings of this case study show that there is a need for more case studies of green crime in the rural industrialized nexus to build evidence for the need for systemic change (Eman and Meško, 2020). Part of this systemic change is redefining "development" related to sustainability and the SDGs. We cannot expect to achieve sustainability using the same economic rationale that has produced issues of the planetary boundaries and the need for the SDGs. A redefined version of the SDGs should include a goal of transforming the structure of the economy to match the needs of local socio-environmental communities to ensure pollution is not being produced beyond the capacity of ecosystem renewal to maintain threshold standards. We cannot continue to allow capital accumulation to define the SDGs. The SDGs and WEF nexus management must also take on the enormous task of transforming the rationalization of individuals. Following Gould and colleagues (2008), the cultivation and strengthening of sustainability ideology and building support for a radical democratization of policymaking are needed. This radical democratization within nexus management can be fostered by implementing cooperative management and grassroots inclusion in decision-making to promote just outcomes (Allouche and colleagues, 2019).

Considering that the societal demands for energy and agriculture are projected to continue to expand in rural areas, it is urgent to align rural nexus industry management with the capacity of ecological renewal to avoid exceedance of water pollution safety thresholds. Considering the findings of this case study, this is not easily done, but there are paths to take to slow the treadmill of destruction. The green criminology approach to using scientifically defined thresholds for industrial water pollution provides a vital method to conduct further case studies, share knowledge, and hopefully change criminal laws for water pollution to be based on social and environmental health needs. Generally, methods to align nexus industries with ecological renewal constraints include decarbonization and regenerative agriculture. These methods demand just transitions and government programs like the Green New Deal.

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Chapter 5 Final Conclusions

Because it is a master variable, water is at the center of concerns for sustainability management (Boltz et al., 2019; Gleick, 1998; Wiek and Larson, 2012). Under increasing pressures of global change and growing concerns for water availability, the WEF nexus has emerged as a conceptual and computational model for sustainability management. Managing the WEF nexus for sustainability is one of the grand challenges of the 21st century, representing a space for social change (Allouche et al., 2015; 2019). Although the WEF nexus has facilitated interdisciplinarity and greater comprehension of inter-sectoral dependencies and pressures on water resources, conventional methods for research and management have been dominated by the natural sciences and primarily driven by economic growth imperatives (Wiegleb and Bruns, 2018a; 2018b). These methods and imperatives reinforce the acceptance of technical solutions to sustainability and threaten to reproduce the structural inequality inherent to the social structure of capitalism (Harvey; 2018; Lövbrand et al., 2015; Peet, 1977). For example, with WEF nexus framings being based on a neoliberal water security agenda to attain food and energy security, questions of environmental injustice and structural inequality tend to get placed on a backburner or omitted entirely (Allouche et al., 2015; Wiegleb and Bruns, 2018). While there has been progress in bringing local social dynamics into nexus research, local environmental degradation stemming from nexus processes at the intersection of local social dimensions remains a primary research gap (Biggs et al., 2015; Liu et al., 2018; Albrecht et al., 2018; Allouche et al., 2019).

In recognition of the inadequacy of conventional approaches to WEF nexus research and management and with an aim to decolonize the sustainability movement, this dissertation contributes a variety of radical and social science approaches to nexus research. The dissertation broadly asks, as a complex SES, how the WEF nexus is influenced by the broader political-economic system. A mixed methods case study of the rural industrialized WEF nexus of Kern County, CA, was conducted. The case study moved beyond technical explanations and solutions typical in WEF nexus research and management by conceptualizing local socio-environmental processes as embedded within and operating according to broader patterns and relations of domination stemming from the global economic system of capitalism (Wilson et al., 2019; Adler et al., 2007; Harvey, 1990; Peet and Thrift, 1989; Allouche et al., 2015; 2019). Each chapter of this dissertation contributes answers to the broad research question, fills gaps in WEF nexus research, and provides complimentary insights relevant to the rural WEF nexus for sustainability management.

Chapter two of the dissertation joined the limits to growth to Marx's metabolic rift theory as the theoretical frame to investigate water pollution stemming from the rural nexus industries of fossil fuel development and industrial agriculture and provide critical political economy explanations. The research hypothesized that the limits to growth (industrial expansion) had been exceeded. The hypothesis was tested using a distance-based approach to mapping risk for exposure to nexus industry-related pollutants in Kern County's tap water per zip code using California's public health goal safety thresholds. Results supported the hypothesis. Rural WEF nexus industry-related pollutants in tap water generally exceeded the safety thresholds in the valley portion of the county and increased with proximity to nexus industry pollution sources.

A primary implication of chapter two is that the rural industrialized nexus of Kern County is producing pollution exposure risk. Drawing from the theoretical frame, this pollution exposure risk is stemming from three main systemic functions within the demands for infinite industrial expansion and the ecological limits for ecosystem renewal. Those functions include an "overshoot" of the capacity for local ecosystems to filter and recycle toxins, a positive feedback (erosion loop) causing a downward spiral of socio-environmental health stemming from infinite economic growth, and a negative feedback in the system signaling a need for social change as indicated by many safety thresholds being crossed (Meadows et al., 1992). Similarly, Marx's metabolic rift theory provided critical theoretical explanations for the spatial analysis based on the contradictions between capital accumulation and the system's capacity for ecosystem renewal (Foster, 1999; 2000). For example, the spatial analysis showed that the threat of pollution exposure risk got greater with proximity to nexus industry sources of pollution, thus symbolizing the metabolic rift as a crisis of capitalism (Foster et al., 2010). This dynamic of uneven geographical development that emerges from capitalist industrial development in the rural WEF nexus represents the antagonism between town and county, considering Kern County's nexus supports its export economy (Foster, 2000; Napoletano et al., 2019). Another symbolization of the rift is the metabolic connection between humans and the environment and the threat of embodiment of industrial pollution stemming from the contradictions of capitalism (Moore, 2015).

Chapter two revealed that the influences of the broader political-economic system on the rural WEF nexus contradict sustainability, having implications for environmental injustice and the planetary boundaries for a safe operating space for humanity (Rockström et al., 2009; Foster et al., 2010). The chapter provided strong evidence of the need for social change for sustainability management and that the WEF nexus is an essential space for that change (Escobar, 2015). Critical pathways to sustainability in the rural WEF nexus include degrowth, post-development, Buen Vivir and the rights of nature, and biocentricity (Escobar, 2015; D'Alisa et al., 2015; Kothari et al., 2019; Borràs, 2016; Matthews, 2019; Shiva, 2008).

Chapter three promoted the use of social science approaches and rooted the research to the local community thus filling a key gap in WEF nexus research by including local social dynamics as part of nexus processes (Albrecht et al., 2018; Bruns et al., 2022; Wiegleb and Bruns, 2018). Chapter three evaluated the two interdependent dimensions of sense of place, place meaning and place attachment, as drivers of perceptions of the impacts of industrial agriculture and fossil fuel development in the pollution exposure risk zones delineated in chapter two (Jacquet and Stedman, 2013; Weeks, 2023). Factor analysis and bivariate correlation analysis showed that place meaning and place attachment are not only drivers of perceptions of impacts, but also drivers for concerns for changes to WEF nexus industries, such as decarbonization. The results also showed that air quality, and lesser so water quality, the economy, and trust in local government have been negatively impacted by WEF nexus industries. As complementary to these findings, the qualitative survey responses revealed that Kern County residents are strongly attached to nexus industries because of their long-term integration into the community, particularly the fossil fuel industry. Relatively, the qualitative survey responses also revealed that residents of Kern County view the fossil fuel industry as a primary source of monetary support for essential community organizations such as the police and fire departments and schools. This represents a key aspect of place attachment being a driver of concern for changes to the fossil fuel industry.

There are key implications of the findings of chapter three for sustainability management in the rural industrialized WEF nexus. Like chapter two, the results showed there are environmental justice issues in the rural industrialized WEF nexus considering most participants perceived air quality, tap water quality, and pollution exposure risk to be negatively impacted by nexus industries. Considering the status quo for development contributes to be towards industrialization and that fossil fuel and industrial agriculture are rural industries that continue to expand and occur in proximity, this case study provides important insights for underdeveloped regions for development planning. For example, while heavily industrialized regions like Kern County need to implement just transitions and non-toxic agricultural practices, underdeveloped regions may have options to base development on the critical pathways to sustainability found in chapter 2 such as Buen Vivir and the rights of nature, and biocentricity which includes regenerative agricluture (Escobar, 2015; D'Alisa et al., 2015; Kothari et al., 2019; Borràs, 2016; Matthews, 2019; Shiva, 2008). Another key implication of chapter three for sustainability management or transitions is that place meaning and place attachment were found to be drivers of the perceptions of the impacts of nexus industries while also being drivers of concerns for changes in WEF nexus industries. SoP can thus serve as a mechanism to initiate systemic changes needed for sustainability management, or against those needs. Nurturing place identity and meaning as being aligned with a healthy environment provides an important path forward.

Chapter four conducted a pollution exposure risk assessment and explored the social dimensions of experience and rationality in the rural industrialized WEF nexus using critical thematic analysis and a green criminology lens (Lynch et al., 2017; Mennis and Heckert, 2018; Mennis, 2002; Meng, 2015; Braun et al., 2019; 2022; Lawless and Chen, 2019; Thompson, 2022). The chapter's mixed methods case study contributed a radical approach to WEF nexus research and suggested a redefined version of the UN's sustainable development goal 6 – clean water and sanitation. The research used quantitative water quality data and qualitative survey responses to ascertain if green crime is occurring in the WEF nexus of Kern County and how political-economic structures are shaping socio-environmental experiences and rationalization. Chapter four built from chapter two, using California's public health goal safety thresholds for the spatial analysis of nexus industry-related chemicals in tap water (Mennis and Heckert, 2018; Mennis, 2000; Meng, 2015; Parris and Kates, 2003). Critical thematic analysis of qualitative survey responses regarding the impacts of nexus industries produced nine codes, five of which fed into an initial theme of political-economic rationale, which fed into a refined theme of the treadmill of production (Braun et al., 2022; Lynch et al., 2018; 2020). A final theme of unequal (ecological) exchange provided an unexpected link between the treadmill of production and the third final theme of green crime – ecological disorganization and socio-environmental injustice. The chapter also problematized economic rationale in sustainable "development" and as a local social dimension in the WEF nexus with the nexus representing the treadmill of production. Evidence from the case study provided the basis for a critique of the sustainable development goals being based on triple bottom line of people, planet, and profit as a neoliberal articulation of sustainable "development."

A primary implication from chapter four for sustainability management is the evidence that rural industrialized WEF nexus is producing harms in the form of ecological disorganization, environmental injustice victimization, and unequal ecological exchange (Lynch et al, 2017; 2019; Wallerstein, 1974). This directly contradicts the sustainable development goals and provides further evidence for the need for social change to achieve sustainability based on environmental quality and social equity. Another primary implication from chapter four for sustainability management was that environmental problems cannot be reduced to capitalism alone because the problems are also driven by the logic or rationale of geopolitics (Hooks and Smith, 2004). Redefining the sustainable development goals to truly attain sustainability must also take on the enormous task of transforming the logic and rationalization of individuals.

5.1 Recommendations for Further Research

Several recommendations for further research materialized from this dissertation. The theoretical frame, which hinges the tenet of the limits to growth that Earth has finite natural resources and pollution sinks to Marxian critical theory, provided a radical approach to WEF nexus research that should be applied in further case studies of the rural industrialized WEF nexus. Further case studies of water pollution being produced by rural WEF nexus industries need to be taken on to support the development of a database which may be useful for quantifying the planetary boundary of novel entities (Rockström et al., 2009; Richardson et al., 2023). Further case studies could also build evidence for the need for social change to align the political economic system with the capacity of ecosystem renewal. Relatively, further research should engage with a promote rural WEF nexus management based on sustainability transitions discourses. This will support reducing pollution inputs which are needed in rural industrialized regions such as Kern County where industrial agriculture and fossil fuel development are leading industries.

The investigation of place meaning and place attachment as drivers of the perceptions of the impacts of rural WEF nexus industries revealed several critical research agendas. With the majority of survey participants perceiving air quality, tap water quality, and pollution exposure risk as being negatively impacted by nexus industries, there is a need for environmental justice research in the rural industrialized WEF nexus of Kern County and other rural regions that have undergone intense industrial development. As a form of praxis, research that engages with the local community in the rural industrialized nexus is needed to nurture place identity and meaning to be aligned with environmental protection. This can be achieved through education, ecosystem restoration, or other activities to remediate the impacts of the fossil fuel industry and industrial agriculture.

This research demonstrated the importance of social science and the investigation of social dynamics in WEF nexus research and for sustainability management. Further research on SoP, particularly place meaning and place attachment, as associated with the perceptions of the impacts of rural WEF nexus industries are needed. This will provide contributions to gaining a better understanding of SoP as a mechanism for sustainability management as well as the experiences of pollution stemming from WEF nexus processes. Drawing from chapter four, further research on the social dimension of political economic rationale in the rural industrialized nexus needs to be taken on. This can support the immense challenge of changing rationale that contradicts sustainability needs. Following Gould and colleagues (2008), research should aim to cultivate and strengthen sustainability ideology and build support for a radical democratization of policymaking. To do this, research in the rural WEF nexus needs to encourage cooperative management and grassroots inclusion in decision-making to promote just outcomes (Allouche and colleagues, 2019).

Finally, the green criminology case study in chapter four provided important directives for research in the rural WEF nexus to encourage detoxification of water and environmental justice. For example, the green criminology approach of using scientifically defined thresholds for industrial water pollution provides a vital method to conduct further case studies, share knowledge, and hopefully change criminal laws for water pollution to be based on social and environmental health needs. Additional case studies of green crime in the rural industrialized WEF nexus should also investigate the embodiment of pollution as an aspect of the metabolic rift.

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Appendix A

Spatial Analysis Data

This appendix contains the data for the spatial analysis of the levels of water-energy-food nexus-related chemicals in tap water per zip code in Kern County, CA. The data is open source. The zip codes came from the US Census Bureau and the water pollution data came from Environmental Working Group's (EWG) online water quality database which provides water quality data per zip code throughout California. EWG gets their water quality data from California water management water quality reports and provides an updated report periodically (EWG, 2021). This data is from the 2021 report. Chemical measurements are in parts per billion except for nitrate which is measured in ppm.

Zip Code	TTHMs	Chromium 6	HAA9	Arsenic	123-TCP	Nitrate	DBCP
16	0	0	0	0	0	0	0
93203	4.09	0.571	0.369	19.3	0.031	1.48	0.00755
93204	54.1	0.0957	38.6	0	0	0	0
93205	0	0	0	8.18	0	0	0
93206	3.55	0	0	4.18	0	0.487	0
93207	2.36	0	0	8.31	0	0.065	0
93215	7.34	6.61	6.41	0.597	0.00291	5.34	0.0258
93219	0	8.06	0	0	0.00801	3.8	0.00775
93222	7.12	0	0	5.61	0	0.854	0
93224	19	0.731	27.9	1.47	0	1.8	0
93225	35.4	1.45	0	2.18	0	2.78	0
93226	0	0	0	0	0	0.473	0
93238	0	0	0	0	0	0	0
93239	27.1	0	0	12	0	0.419	0
93240	0	0	0	8.18	0	2.86	0
93241	2.49	4.09	0.736	8.82	0.0136	2.82	0.0106
93243	35.4	1.45	0	2.18	0	2.78	0
93249	30.3	0.49	0	8.93	0	0	0
93250	5.02	6.08	2.28	8.53	0.00457	5.61	0
93251	19	0.731	27.9	1.47	0	1.8	0
93252	19	0.731	27.9	1.47	0	1.8	0
93255	4.54	0.11	0	0.127	0	1.5	0
93263	7.8	2.4	2.28	4.59	0.0928	6.14	0.0119
93268	19	0.731	27.9	1.47	0	1.8	0
93276	19	0.731	27.9	1.47	0	1.8	0
93280	5.41	3.99	0.843	1.94	0.0505	7.29	0.0164
93283	12.4	0	0	0	0	3.65	0
93285	21.7	0	0	4.07	0	0.864	0

93287	0	0	0	0	0	0	0
93301	36.6	0.68	39.6	2.51	0.0014	2.03	0.000142
93304	36.6	0.68	39.6	2.51	0.0014	2.03	0.000142
93305	36.6	0.68	39.6	2.51	0.0014	2.03	0.000142
93306	36.6	0.68	39.6	2.51	0.0014	2.03	0.000142
93307	36.6	0.68	39.6	2.51	0.0014	2.03	0.000142
93308	43.08	0.336	54.5	0	0.000272	1.96	0
93309	9.66	0.636	16.8	2.38	0.0304	1.76	0
93311	9.66	0.636	16.8	2.38	0.0304	1.76	0
93312	9.66	0.636	16.8	2.38	0.0304	1.76	0
93313	9.66	0.636	16.8	2.38	0.0304	1.76	0
93314	6.15	0.391	0.824	1.38	0.00119	3.25	0.00134
93501	35.4	1.45	0	2.18	0	2.78	0
93505	35.4	1.45	0	2.18	0	2.78	0
93516	35.4	1.45	0	2.18	0	2.78	0
93518	0	0	0	0	0	0	0
93519	35.4	1.45	0	2.18	0	2.78	0
93523	35.4	1.45	0	2.18	0	2.78	0
93524	35.4	1.45	0	2.18	0	2.78	0
93527	3.03	0	0	2.07	0	2.04	0
93528	0	0	0	0	0	0	0
93531	12.2	3.18	0	3.94	0.000523	3.7	0
93536	35.4	1.45	0	2.18	0	2.78	0
93554	35.4	1.45	0	2.18	0	2.78	0
93555	3.06	1.04	1.22	1.14	0	1.91	0
93560	35.4	1.45	0	2.18	0	2.78	0
93561	12.2	3.18	0	3.94	0.000523	3.7	0

Appendix B

This appendix contains the English and Spanish version of the survey that was distributed to residents of Kern County who live in the pollution exposure risk zones.

Survey (English Version)

Kern County Residents Matter!

You are being asked to participate in a research study. This research aims to learn about the experiences, and points of view, of individuals living near fossil fuel development and/or industrial agriculture as these industries intersect with water and the communities of Kern County.

Benefits: Your responses to the survey questions will provide important insights into Kern County resident experiences which may ultimately influence local planning and management decisions.

Procedures:

- Please provide responses to all questions of the survey and any additional insights you feel are important in the space provided. The questionnaire should take less than 10 minutes to complete. Your responses are completely anonymous.
- **You are asked to return the completed survey using the included postage-paid envelope.**

Your completion of this survey implies your consent to take part in this research.

Thank you so much for taking the time to read, complete, and mail this survey.

To what extent do you agree or disagree with the following statements about Kern County?

	Strongly disagree	*Disagree*	*Neutral*	*Agree*	*Strongly agree*
The environment is healthy	☐	☐	☐	☐	☐
It is a good place to get away	☐	☐	☐	☐	☐
It has outstanding natural beauty	☐	☐	☐	☐	☐
It has great outdoor recreation	☐	☐	☐	☐	☐
The community is very friendly	☐	☐	☐	☐	☐
The community is close-knit	☐	☐	☐	☐	☐
I stay here for job security	☐	☐	☐	☐	☐
I would not want to live anywhere else	☐	☐	☐	☐	☐
I am deeply connected to this place	☐	☐	☐	☐	☐
My job is connected to the land	☐	☐	☐	☐	☐
Water quality is in decline	☐	☐	☐	☐	☐
The economy is in decline	☐	☐	☐	☐	☐
I am worried about sustainability in Kern County	☐	☐	☐	☐	☐

Please identify how <u>agricultural development</u> has impacted Kern County (Negative = damaged/gotten worse, Positive = improved/gotten better)

	Very Negative	Negative	Neutral	Positive	Very positive
Water quality	☐	☐	☐	☐	☐
Air quality	☐	☐	☐	☐	☐
Wildlife habitat	☐	☐	☐	☐	☐
Access to water	☐	☐	☐	☐	☐
Scenic beauty	☐	☐	☐	☐	☐
Trust in local government	☐	☐	☐	☐	☐
Community connectivity	☐	☐	☐	☐	☐
Pride in community	☐	☐	☐	☐	☐
Inclusion in planning	☐	☐	☐	☐	☐
Resident health	☐	☐	☐	☐	☐
Pollution exposure risk	☐	☐	☐	☐	☐
Tap water quality	☐	☐	☐	☐	☐
Quality of life	☐	☐	☐	☐	☐
Property values	☐	☐	☐	☐	☐
Job market	☐	☐	☐	☐	☐
Economic health	☐	☐	☐	☐	☐

Please identify how <u>fossil fuel development</u> has impacted Kern County (Negative = damaged/gotten worse, Positive = improved/gotten better)

	Very Negative	Negative	Neutral	Positive	Very positive
Water quality	☐	☐	☐	☐	☐
Air quality	☐	☐	☐	☐	☐
Wildlife habitat	☐	☐	☐	☐	☐
Access to water	☐	☐	☐	☐	☐
Scenic beauty	☐	☐	☐	☐	☐
Trust in local government	☐	☐	☐	☐	☐
Community connectivity	☐	☐	☐	☐	☐
Pride in community	☐	☐	☐	☐	☐
Inclusion in planning	☐	☐	☐	☐	☐
Resident health	☐	☐	☐	☐	☐
Pollution exposure risk	☐	☐	☐	☐	☐
Tap water quality	☐	☐	☐	☐	☐
Quality of life	☐	☐	☐	☐	☐
Property values	☐	☐	☐	☐	☐
Job market	☐	☐	☐	☐	☐
Economic health	☐	☐	☐	☐	☐

Please answer the following questions by checking the box for "yes" or "no"

	Yes	No
I live in Kern County year-round	☐	☐
I have lived in Kern County my whole life	☐	☐
I am female	☐	☐
I am male	☐	☐
I am Native American	☐	☐
I am African American	☐	☐
I am Latino/Latina	☐	☐
I am Asian or Asian/American	☐	☐
I am white or of European descent	☐	☐
I work in agriculture	☐	☐
I work in the fossil fuel industry	☐	☐
I have a college degree	☐	☐
My highest level of education is high school	☐	☐

Please provide any additional information or insights on what you feel should be addressed regarding the impacts of the fossil fuel industry and/or industrial agriculture on Kern County's water.

Survey(Spanish Version)

¡Las residentes del condado de Kern importan!

Se le está pidiendo que participe en un estudio de investigación. Esta investigación tiene como objetivo conocer las experiencias y los puntos de vista de las personas que viven cerca del desarrollo de combustibles fósiles y/o la agricultura industrial, ya que estas industrias se cruzan con el agua y las comunidades del condado de Kern.

Beneficios: Sus respuestas a las preguntas de la encuesta proporcionar información importante sobre los residentes del condado de Kern experiencias que en última instancia pueden influir en la planificación local y decisiones de gestion.

Procedimientos:

- Proporcione respuestas a todas las preguntas de la encuesta.y cualquier información adicional que considere importante en el espacio proporcionado. El cuestionario debería tomar menos de 10 minutos para completar. tus respuestas son completamente anónimo.
- **Por favor devuelva la encuesta completa utilizando el sobre con franqueo pagado incluido.**

Muchas gracias por tomarse el tiempo de leer, completar y enviar esta encuesta.

¿Hasta qué punto está de acuerdo o en desacuerdo con las siguientes afirmaciones sobre el condado de Kern?

	Muy en desacuerdo	Discrepar	*Neutral*	Aceptar	Totalmente de acuerdo
El el medio ambiente es saludable	☐	☐	☐	☐	☐
Es un buen lugar para escapar	☐	☐	☐	☐	☐
Tiene pendiente belleza natural	☐	☐	☐	☐	☐
tiene un gran exterior recreación	☐	☐	☐	☐	☐
El la comunidad es muy amigable	☐	☐	☐	☐	☐
El la comunidad es muy unido	☐	☐	☐	☐	☐
Me quedo aquí por seguridad laboral.	☐	☐	☐	☐	☐
no quisiera vivir en cualquier otro lugar	☐	☐	☐	☐	☐
Estoy profundamente conectado a este lugar	☐	☐	☐	☐	☐
Mi trabajo está conectado con la tierra.	☐	☐	☐	☐	☐
La calidad del agua está en de-clive	☐	☐	☐	☐	☐
La economía está en declive	☐	☐	☐	☐	☐
estoy preocupado por sostenibilidad en el condado de Kern	☐	☐	☐	☐	☐

Identifique cómo ha impactado el desarrollo agrícola en el condado de Kern (Negativo = dañado/ empeorado, Positivo = mejorado/mejorado)

	Muy Negativo	*Negativo*	*Neutral*	*Positiva*	*Muy positiva*
Agua calidad	☐	☐	☐	☐	☐
Calidad del aire	☐	☐	☐	☐	☐
Hábitat de vida silvestre	☐	☐	☐	☐	☐
El acceso a los agua	☐	☐	☐	☐	☐
Escénico belleza	☐	☐	☐	☐	☐
Confiar en local gobierno	☐	☐	☐	☐	☐
Conectividad comunitaria	☐	☐	☐	☐	☐
Orgullo en comunidad	☐	☐	☐	☐	☐
Inclusión en la planificación	☐	☐	☐	☐	☐
Salud del residente	☐	☐	☐	☐	☐
Contaminación riesgo de exposición	☐	☐	☐	☐	☐
Calidad del agua del grifo	☐	☐	☐	☐	☐
Calidad de vida	☐	☐	☐	☐	☐
Propiedad valores	☐	☐	☐	☐	☐
Mercado de trabajo	☐	☐	☐	☐	☐
Salud económica	☐	☐	☐	☐	☐

Identifique cómo el desarrollo de combustibles fósiles ha impactado al condado de Kern (Negativo = dañado/empeorado, Positivo = mejorado/ mejorado)

	Muy Negativo	*Negativo*	*Neutral*	*Positiva*	*Muy positiva*
Agua calidad	☐	☐	☐	☐	☐
Calidad del aire	☐	☐	☐	☐	☐
Hábitat de vida silvestre	☐	☐	☐	☐	☐
El acceso a los agua	☐	☐	☐	☐	☐
Escénico belleza	☐	☐	☐	☐	☐
Confiar en local gobierno	☐	☐	☐	☐	☐
Conectividad comunitaria	☐	☐	☐	☐	☐
Orgullo en comunidad	☐	☐	☐	☐	☐
Inclusión en la planificación	☐	☐	☐	☐	☐
Salud del residente	☐	☐	☐	☐	☐
Contaminación riesgo de exposición	☐	☐	☐	☐	☐
Calidad del agua del grifo	☐	☐	☐	☐	☐
Calidad de vida	☐	☐	☐	☐	☐
Propiedad valores	☐	☐	☐	☐	☐
Mercado de trabajo	☐	☐	☐	☐	☐
Salud económi-ca	☐	☐	☐	☐	☐

Responda las siguientes preguntas marcando la casilla de "sí" o "no"

	si	*no*
Vivo en el condado de Kern todo el año.	☐	☐
He vivido en el condado de Kern toda mi vida.	☐	☐
soy mujer	☐	☐
soy hombre	☐	☐
Soy nativa americana	☐	☐
Soy afroamericana	☐	☐
Soy latina / latina	☐	☐
Soy asiática o asiática / americana	☐	☐
Soy blanca o de ascendencia europea	☐	☐
yo trabajo en la agricultura	☐	☐
Trabajo en la industria de los combustibles fósiles.	☐	☐
tengo un titulo universitario	☐	☐
Mi nivel de educación más alto es la escuela secundaria	☐	☐

Proporcione cualquier información adicional o ideas sobre lo que cree que se debe abordar con respecto a los impactos de la industria de los combustibles fósiles y/o la agricultura industrial en el agua del condado de Kern.

Appendix C

This appendix contains the (long answer) qualitative survey responses (N = 100) from the survey.

Qualitative survey responses

Both industries together make California what is was and is. Look at the taxes they pay. Donations to the community, jobs, and taxes paid by the workers. There is 1000 of barrels of water taken from oil and injected back in the ground. It can be cleaned up for cheaper to inject it into the ground. Ag is for food, oil is for everything else. Wind turbines made from fossil fuel products; Tesla cars made of 80% fossil fuel products.
My disagreement is with the state of California and not with Kern County
As a Kern County resident, I do appreciate the works of our fossil fuel agencies. Without the oil provided we would not be able to produce the many things we enjoy today. I would rather our oil come from our soil. Americans have many wants and needs when it comes to quality living, especially here in Kern County. The only issue about life here is the terrible air quality. I have yet to see any movement on air quality. Another issue is the mental health of all of the homeless people out here on the streets. Many of them suffer from various mental health issues and there is nowhere to house destructive people like them. Most take shelter in alleyways, under bridges, near our businesses in town. They also cause a lot of damage to properties in all different areas of Kern County. **There are** a lot of people suffering from low wages and a high cost of living for a place that is so heavily polluted.
I live in the worst part of Bakersfield. There is an alley behind my "hut" always full of trash, junk, weeds out of control. I am a senior female. I try to clean up by myself. Sometimes I can't. Why does everyone in the city ignore us? We pay our bills!!
People are too attached to fossil fuels and wasting water and recycling not important enough. People don't care and look for politicians who support the petrochemical agenda.
I think we should stop pumping oil from soil.
The oil industry provides quality, decent paying, jobs in this community that wouldn't exist without the oil industry.
Bakersfield has a criminal problem due to many factors Put the law enforcement back in the way it was. Kern County is known as a prison valley and we do end up with those deadbeats. We need our roads fixed more than we need the highway 58 exchange. We pull all the fossil fuels so when is this county going to have a police officer or two and a drug/gun dog at every school from k-12? We have a bad problem with the good kids getting hurt or baited into something. Sick of seeing twiddling thumbs. Let's see some action.
We don't even use our own oil that we pump out of the ground. For as much oil production, why are gas prices so high?
I believe farmers should not be water-limited because that limits food production which decreases income and growth. Keep our food local first. I have lived in Kern County for 40+ years family contracting agriculture and have seen many changes for the worst impacting our people. I'm not against change. I am against unnecessary change and limits. We are a great community that provides many diverse things that's why I have stayed here. Please conserve this water we have been so blessed to get this winter. Don't let it ship away. Let our farmers use it.

I believe the water in Kern County is very safe! It's the amount of people and building more homes is a big problem. Ken County needs agriculture and fossil fuel to feed and fuel the nation.
Both industries use too much water. The Wonderful Company is scary, due to its purchasing lad with H2O rights. Small towns are impacted the most in the case of water and air quality (farmworker residents).
I raise beef cattle. They are great for fire reduction. Would like to see road county maintenance - clear dead grass from side of road or disc like fire dept does on part of Granite Rd. Clearing brush is vital for fire reduction and air quality. Open up the oil industry so people can get back to work.
I have in the middle of the oil fields for 16 years. I have seen the oil industry destroy my town (Derby Acres). The park has been stripped away piece by piece. Oil steam systems are bled down onto the community, blowing nasty toxins into the air that blows into my home by swamp cooler (smells horrible). Now they are buying up homes and boarding them up. Makes it hard to sell my home.
After leaving Kern County for 20+ years it's hard to know where to begin. I spent 10 years living in Oregon just outside of Portland and working in Portland. The focus of life in that area is to live in harmony with nature - to preserve the beauty. Is that outlook even possible in Kern County? What about starting with a beautification program? Pick up your trash? Keep the freeways picked up? And stiff fines on those who dump illegally? How do we change consciousness? Right now Kern County is filled with the objective to make money, money, money and leave the mess behind.
I feel it is better to produce oil in Kern County than buying it from other countries. The large ships that bring the oil to the US pollute the oceans and the air. With the environmental standards that are in place, we can produce oil cleaner than other countries are. Kern County prospers from the oil industry through the land taxes and permit fees that help pay for police and schools. Agriculture is what made Kern County, but Kern County isn't proud of the agriculture that is produced here. It is very important that the US is able to produce enough food to feed itself. IN the past, the US has been dependent on foreign oil which caused higher prices for gas. If we become dependent on other countries for food, the price for feeding a family will go up. We need to produce food in Kern County and stop building houses.
Kern County's water, and for that matter all of the thousands of counties in the US, have a water supply - water is a renewable resource by nature. All water supply should be kept free of pollution. Regarding fossil fuel production and agriculture production, on Kern County's water: the oil and gas exploration and production does not require as much water as the agricultural industry. Industrial ag requires a tremendous amount of water to produce food and/or beef. How to produce more water in addition to using it wisely: Kern County and California should petition the governor to invest in desalinization and set up a series of pipelines to serve the counties on an as-need basis. The ocean would provide all the water California needs plus enough to sell water to the adjacent states, the money made from which could go to paying for the desalinization and pipelines.
Our biggest obstacle to the health and the economy of Kern County is the left-wing politician who is determined to destroy what makes this country viable. The comedian Ron White expressed it best when it comes to democrat leaders, you can't fix stupid.

Neither the fossil fuel industry nor industrial agriculture have a major impact on Kern Water. The problem is no new dams have been constructed and that 80% of excess water goes to the ocean.
Fossil fuel is just as important as clean water
it would be nice to see code enforcement doing their job. Condemning buildings that are no up to standards. Also, the Sheriff's office needs to haul away the junkers parked on the streets, sidewalks, etc. Mechanics working on the sidewalk creates an environment that is not safe for children going to school or even adults. It's time to clean up Bakersfield and make it a beautiful place to live again.
Long term fossil fuel industry will interrupt children's health in the future. Oildale does not consider that our air quality is very low. As a resident of Oildale, I have to avoid the outside air. We can smell gases and burn oil, very frequently, especially morning and night.
Fossil fuel and agriculture have been my two questionable issues here in Kern County. I don't understand why a county that produces a major portion of a natural resource does not share its financial benefits with its communities. We not only do the work but also suffer hazards that are associated with manufacturing and cultivation of these products, yet gas is overpriced and produce costs are becoming ridiculous. If any, we residents of Kern County should be compensated.
I believe the fossil fuel industry does great for the surrounding communities, families and businesses in greater Kern County. If water is a concern in our area, we need to upgrade the water treatment infrastructure with help from the petroleum industries that tap into our waters. I also believe the petroleum industries in our area need to find solutions to reduce greenhouse gas emission as well as the farmers and developers. As a resident of Kern County for many years, we need to find solutions to improve the future of our local citizens for generations to come by making our county a healthier live and raise families including our wildlife.
What does my race matter? We are all suffering here in Kern County. Food prices and gas prices are a direct result of Gavin Newsom's rule. Do you even really care about this survey? What will it change?
Everyone who lives in Kern knows to not drink the water. The water has had many years of pesticide runoff. There is no way to clean it. Also, many people in Kern County take radiation for cancer. All that ends up in the water.
The almond industry takes our water and ships its products overseas. The oil industry is ruining our water and land.
Agriculture and fossil fuels are needed by everyone. Agriculture and fossil fuels are a win win for the county. Los Angeles and San Francisco need us, we don't need them. Ag and oil jobs affect everyone and are needed for the survival of the state. As far as water goes, the ocean is full. Ocean don't need more water now or ever. Grew up on a family farm. The price of water and electricity pushed us out. Finished in oil fields. Both jobs are good ways to raise families.
Having worked in the fossil fuel industry for many years, I know personally the oil companies make every effort to protect and defend the natural habitat, endangered species, and even environment. The fossil fuel industry is crucial for Kern County as far as employment for many residents, crucial for our economy, and the sustainability for Kern County and the USA.
Kern County needs fossil fuel and we need water for agriculture. These industries are what make Kern County!

Who are you and what kind of trouble are you wanting to foment? The devil will not survive here.
We need oil in Kern County. We have many people working in the oil fields. Keep it here.
I am most concerned about affordable housing, health insurance, and violent crime.
Fossil fuel is the primary source of income in the oil industry area of Kern County. Air pollution scrubbers filter out 99% of carbon dioxide. Air in the valley is highly concentrated with pollution from Washington, Oregon, and Canada. To take away fossil fuel is to eliminate Kern County. We must fight to keep fossil fuel and ag income.
We need more farming and more fossil fuel development. Fuel prices need to come down. There are homeless people on every corner and around all businesses, which is very scary for children and the elderly. We need more police.
I like the scenery. It changes specifically in agriculture and it's interesting. Living here is not too much hassle every day, not like in the city where there is too much traffic and it is crowded.
I think the hard-working farmers should receive the water they need
Agriculture and fossil fuel are what make Kern County. We need to grow both industries to see continued growth and impact on our community.
Is bio-waste shipped into Kern County from other areas?
Give the farmers the water they have paid for. Fossil fuel industry lacks jobs because of state regulations.
We should go back to E1 gas. It works.
I recently purchased a water filter pitcher and it had a tester for water purity. I tested my tap water and it tested in very acceptable range. I live close to where fossil fuel is extracted so Kern County is doing a great job providing clean water.
Drill baby drill
Regarding the impacts of these industries on water, you guys got a long way to go, long way!
The fossil fuel industry is an important part of Kern County and should not be shut down. Many jobs would be lost or curtailed. Do not let Gavin Newsom close down our fossil fuel industry. Fossil fuel and agriculture need to work together to maintain out air, soi, and water quality.
You are doing the best you can
Anything that allows more jobs and more opportunities of employment is good.
Our fossil fuel industry is very important as well as agriculture. Our governor has it all wrong. We need less restrictions on both industries. We need more access to water from the north. This is the bread basket of the world.
Agriculture is an industry that is not only much needed, but crucial to Kern County. There needs to be a way where water is equally shared with farmers but also safe for the residents. The water pipes in towns/cities are horrible quality and we are suffering and you can see it in all of the health issues. Not only the water, but the air we breathe! Do better Kern! We are top producer in agriculture in the nation yet we have the worst air quality and health conditions. The residents deserve better and that goes for wildlife too. We see all this new development and that's great but its also pushing out more and more wildlife. We need to stop and think about the effects of urban development on agriculture culture as well. We need to preserve more of the wild habitat and work on restoring resident health. Get the

parks and recreation looking good again and fix the quality of water. That way we can have more pride in the community.
Almond harvesting makes our air quality bad bad! Products that go overseas after using our water to grow them making our air quality the worst in the US at harvest time. Cut the water used to irrigate the almonds to about half with restrictions on almond production. Keep almonds out of the valley. This would save air quality and save water. Fuck the almonds.
It is not a good idea for Governor Newsom to deny permits for oil drilling in Kern County. Drilling for oil in our own county and state could go a long way towards lowering gas prices. Governor Newsom is trying to force California residents to switch to electric cars or hybrids. Most of them are very unattractive and none of them are affordable.
If I had the money to move out of here, I would. Out of California even better.
Agriculture and fossil fuel are essential to Kern County and California's economy. The industries strive to be good stewards of the land and coexist with neighbors. County boards should not approve projects that abut existing agricultural lands and fossil fuel operations. Kern County is unique in that a lot of pollution comes from northern sources: SF Bay, Sacramento, and Fresno. We also have three transportation highways that contribute dust and exhaust.
Fossil fuel impacts include positive impacts but negative impacts because it creates new problems. In 200-300 years, the government may say it causes people to die. The fossil fuel industry impacts my family through the price of gas. Industrial agriculture water must be cleaner. Dumping bad/dirty water to the ocean will make all of the fish poison and thus poison food for people.
The most important thing is the water. I have had to buy drinking water all my life and all of the people are tired of having to buy water all year long in Arvin.
The agricultural industry needs to use less pesticides. It takes water to grow crops so hopefully we can keep farming here. I'm not in favor of the fossil fuel industry. I believe in climate change. We need farmland, not more fossil fuel.
The impacts of the fossil fuel industry and industrial agriculture are low compared to the contribution to the economy of Kern County.
Kern County has a bright future. The only problem is our government at the state capital. Trying to eliminate fossil fuel is utter nonsense. Our country is agriculture and oil. Many jobs rely on it. Not just the workers. We need tax dollars for the support of our fire fire departments, police, sheriff dept and roads. It will affect everyone! Leave the oil and ag industries alone. They are already regulated to death.
Kern County is agriculture and fossil fuel. Keep it that way!
No matter what industry, companies should be environmentally friendly and good neighbors. I work in agriculture and live close to fossil fuel industry.
Leave the oil industry alone!
Deport all aliens, English only. Put all homeless in prisons.
The water is like our air quality, terrible.
The idiots that control the water - don't have enough places to save the water. No planning ahead.
I believe too much is made of climate change. Our government is ruining our country. We need the oil industry here. Newsom is ruining California. Pollution is not as bad as it was 20 years ago. There are jobs if people want to work.

Agriculture and fossil fuels are key industries for Kern County. The agriculture and oil companies need the resources they use but they need to use them wisely. Too much government and legislation does not help.
Water is so important! More care needs to be taken to make sure gets what it needs to grow food. People deserve good, clean, healthy water to drink and use in our homes. Fossil fuel has been an important contributor to our economy, schools, community outreach, and more. We all use fossil fuel products, even if we go as green as we can. More care needs to be taken for both the fossil fuel industry and industrial agriculture to keep unhealthy biproducts of their production out of water and the air we breathe.
I was born and raised in Kern County. My husband worked in the fossil fuel industry for more than 25 years. We are both pro-oil pro-ag. Not in favor of more regulations and buying our oil from over seas.
We need our oil! Don't take it away.
I traveled to Europe many times. Loved the trips but always anxious to get home to Kern County!
Taking away good jobs with no job replacements. There are not enough full-time jobs. The rent is too high. Homeless people need low-income housing.
Fossil fuel is important to Kern County jobs and county economy, also the state.
Kern County water has been sold to Los Angeles, yet they refuse to build desalinization plants. Nuclear power has been discontinued with no replacement. Co-generation plants have been closed - don't like natural gas.
I am not too fond of our water situation here. It should and could be better by all means necessary.
The air quality here is horrible because I step out in the morning to that awful stench of gasoline toxins. I have been awakened a few nights by that horrible smell which has also woken me up early in the morning. As an individual with lung disorders, this is horrible. And the way the economy is I really don't have many choices as to what area to live in. Don't get me wrong, I love my house but if I could relocate it I would. I enjoyed the location in advance to purchase because we were a short distance to the bluffs.
A high density, low income, development is planned to be constructed in a vacant lot across the street from an oil refinery. This would not be healthy for the residents.
I don't feel these industries have an impact on water, I feel our corrupt state government is not doing enough to help with water storage for farming. Also, the development of farmland into housing developments is detrimental to the county. I hate how our cities are growing and turning our county into urban wastelands.
Fossil fuel is essential to the economy in Kern County. Many people relied on work in the oil fields. Too many people will be affected if the industry is disrupted or discontinued.
We need more campaigning about air quality and to teach children about the issue. Social media would be a good place to spread information about water pollution stemming from industrial agriculture and fossil fuel development.
Kern County residents' water source is dry.
Rural areas around Kern County are often disregarded (city of Arvin) regarding water quality and agriculture practices (like spraying chemicals within city limits).
Houses should not be built so close to agricultural fields as out water and air is exposed to the chemicals used. We have poor water quality. It smells bad. Purchasing bottled water at

the local store is expensive. The basic cost of living is expensive. We cannot go for five to six days without a pink colored texture being formed around our tub drain and toilet.
Expand fossil fuel development and industrial ag to pay for cleaning up trash around Kern County.
I am Christian and I know prophesy so I know the future is going to get worse. Kern County will need fossil fuel and industrial agriculture to survive Armageddon.
Improve farmworker housing and health
We need fossil fuels for our vehicles and for commerce. We cannot go green overnight. We are not ready to switch to all electric. If we go green over night our country will be in very big trouble. California is overcharging for fuel.
Kern County exists due to the fossil fuel and agriculture industries. Those who oppose either or both vital, crucial industries are shortsighted at best
Residents are always wondering, what are those loud explosions we occasionally hear from local refineries. Why are local gas prices so high when we live right next to refineries? Why is the produce offered at our local markets so awful? I live in Oildale. Anyone in Kern County should not have this complaint! We should have the best fruit and produce here. We put up with crop dusting. I don't understand why the fruit here has no flavor or it never ripens. If you do get something that looks good, it rots the next day. Food like this should just be fed to pigs, not us people.
Deregulate both industries. Make it easier for these industries to do business so they can hire more people, pay more money, and create more wealth. Liberals have turned this beautiful state int a shithole. I am so close to relocating my business to another state like so many businesses have already done.
Our air quality is out of control. Our town looks like crap. Our roads are tore up. The homeless population has turned our town to shit.
Either the agriculture personnel or the fossil fuel personnel should go around their neighborhoods and provide water testing to appease residents.
Water quality is bad. Everyone keeps to themselves except the homeless and and druggies and their drug dealers
There are both positive and negative that are natural biproduct of the fossil fuel industry. The negative are negligible. Best thing for this or any area.
I don't think the government should be allowed to control the industry that has sustained our county for so many years. The country can't produce enough electricity for our houses and businesses, much less force us to drive electric vehicles. So don't restrict fossil fuel production.
It is called the oil industry. It is very important to Kern County and the US. Only an idiot would try to curtail this vital production.
I know our water in Kern is tainted and undrinkable. Either the river is overflowing or is shut off. No water slides, no water parks, no water fun.
I lived in Kern County 65 years. The Earth is so polluted from farming and oil fields. The wind blows all kinds of diseases around. Valley Fever is horrible. There's nothing to do but go out to eat. There's not enough water to enjoy. The politicians are awful and the homeless are out of control. People use to be friendly but that's going south. I know Kern County residents come together when a disaster hits. The young people are getting rude to older people and no one has respect for other's property.

Tell the Sierra Club and Environmentalists to take a hike. Oil is this country's life blood. If we would open up drilling all over this country we would tell the foreign oil producers to buzz off. We have more oil in the US than all other countries combined. But the government is keeping the US dependent on foreign oil! It's time for the silent majority to take back our state and government from the politicians. Our poorer air quality is not from oil production. The pollution is from up north and is trapped in the valley and making our air worse but don't blame our oil and agriculture!
Please clean up the tumble weeds before fires start.
It has been more than 2 years since the water rose too high and the community has not been able to help the families. Also in the offices in McFarland CA where they pay the water bill, they don't know how to explain anything about what is happening, they just get angry and don't have a good way of serving people. They don't even know what they are charging, they only charge the same so that one can sign paying the high bills that arrive. I ask you to please do something to help all the families with their bills. This must be bad, what they are charging for the water bill is too much. We have many families who do not have a good job just to survive. You know that we are in crisis and the economy is very weak. I hope my words can help you and put yourself in our place. If possible! United we will win the battle.