Beyond Environmental Determinism: Natural Resources and Environmental Challenges in the UAE's Political Ecology

Van Giessen, Marinus

Beyond Environmental Determinism: Natural Resources and Environmental Challenges in the UAE's Political Ecology

Program:	MA Middle Eastern Studies
Institution:	Leiden University
Supervisor:	Dr. C.J.V. Henderson
Student:	M.A. Van Giessen
Word count:	19,859
Date:	07-06-2023

Table of Contents

Introduction

Oil wars, water wars, food crises, and – making matters worse – climate change looming large. Scholars, analysts, and journalists alike often describe the Middle Eastern environment in terms of calamities and crises.[1] As a result, an image arises of a people that is unable to escape the inevitable doom incited by their natural surroundings. This line of thought is reflected in the literature on human-environment relations in the Middle East through the dominance of theories such as the scarcity conflict thesis, which links environmental scarcity to the onset of intrastate conflict.[2] Not only conditions of scarcity, however, but also of abundance are associated with adverse outcomes in the literature on the Middle East. The resource curse thesis and Rentier State Theory consider resource rents to lead to, amongst others, economic stagnation, conflict onset, and authoritarianism.[3]

This deterministic way of interpreting the relationship between the Middle Eastern environment and its inhabitants has been subject to critique from a growing body of literature on political ecology.[4] Political ecologists argue that sociopolitical realities in the Middle East do not result solely from environmental factors, but from a complex interplay between interconnected variables at the environmental, social, political, and economic level.[5] Although some political ecology research has challenged environmental deterministic assumptions by exploring the role of natural resources in environmental challenges in the Gulf,[6] previous works have not yet provided a comprehensive analysis of various environmental dimensions in a single case study context.

This thesis aims to fill this gap in the literature by asking: What is the role of natural resources in engaging with environmental challenges in relation to water, food, and energy in the United Arab Emirates (UAE)? Building on existing social ecology and political ecology scholarship, I argue that society and nature are intertwined. I hypothesize, first, that natural resources, through complex social, economic, political, and environmental processes that have changed over time, have enabled the UAE to overcome challenges posed by its

---

[1] Clemens Hoffmann, "Environmental determinism as Orientalism: The geo-political ecology of crisis in the Middle East," *Journal of Historical Sociology 31*, no. 1 (March 2018): 103, https://doi.org/10.1111/johs.1219.
[2] Thomas Homer-Dixon, *Environment, Scarcity, and Violence* (New Jersey: Princeton University Press, 1999).
[3] Meliha Benli Altunişik, "Rentier State Theory and the Arab Uprisings: An Appraisal," *The Middle East Journal* 63, no. 3 (Summer 2010): 77–78, https://www.jstor.org/stable/43925852; Michael Ross, "What Have We Learned about the Resource Curse?" *Annual Review of Political Science* 18, (May 2015): 239–259, https://doi.org/10.1146/annurev-polisci-052213-040359.
[4] Hoffmann, "Environmental determinism," 94–104.
[5] Paul Robbins, *Political Ecology: A Critical Introduction* (Hoboken, New Jersey: Wiley-Blackwell, 2012), 11–20.
[6] See, for example: Christian Henderson, "Land Grabs Reexamined: Gulf Arab Agro-Commodity Chains and Spaces of Extraction," *Environment & Planning* 53, no. 2 (March 2021), https://doi.org/10.1177/0308518x20956657; Eckart Woertz, *Oil for Food: The Global Food Crisis and the Middle East* (Oxford: Oxford University Press, 2013); Rachael McDonnell, "Circulations and Transformations of Energy and Water in Abu Dhabi's Hydrosocial Cycle," *Geoforum, Journal of Physical, Human, and Regional Geosciences*, no. 57 (November 2014): 225–233, https://doi.org/10.1016/j.geoforum.2013.11.009; Toby Jones, *Desert Kingdom: How Oil and Water Forged Modern Saudi Arabia*. Cambridge, Mass.: Harvard University Press, 2010.

environment. Second, I hypothesize that oil is central to these processes by granting the Emirati state the necessary power and revenue to set in motion certain approaches to deal with environmental issues. Third, I hypothesize that the ways in which the UAE has dealt with these challenges have, in turn, also solidified its power. Fourth, I hypothesize that this research will not only show that society and the environment are connected but also that various environmental challenges interact with each other.

I will explore the political-ecological metabolisms of three strategies employed to address environmental challenges in relation to water, energy, and food in the UAE: desalination, solar energy, and land grabs. I focus on these specific resources as they are often considered to be connected and treated as a nexus in academic literature.[7] Furthermore, according to analysts, these critical resources are under increasing pressure and, therefore, represent today's most salient environmental challenges.[8] The UAE is taken as a case study since conventional deterministic accounts would expect the Gulf environment to present its inhabitants with particularly excessive hardship, given its simultaneous water scarcity and hydrocarbon abundance. However, reality in the Gulf seems to suggest otherwise, making the case compelling to examine. The UAE is particularly interesting, as it is relatively understudied compared to other Gulf countries, such as Saudi Arabia. Methodologically, I will collect information using primary sources, such as news articles and company websites, as well as secondary sources, including academic literature on the ecology, economy, politics, and history of the UAE.

This research presents a relevant contribution to the academic literature and beyond. First, by analyzing the role of natural resources in environmental management, I add to the academic debate on the placement of agency within human-environment relations. More specifically, by considering water, energy, and food challenges, this study presents a comprehensive contribution to the political ecology literature. Additionally, the findings of this research contain relevant insights for political and social actors, for whom it is crucial to understand the complex processes underlying the interplay between natural resources, human actors, and the broader environment, while climate change will only continue to increase the salience of environmental issues in the Middle East.

In the first chapter of this thesis, *Agency and the Middle Eastern Environment*, I review the literature on human-environment relations in the Middle East. This section also addresses the theoretical framework on which my hypotheses are based. Acknowledging the importance

[7] Alex Smajgl, John Ward, and Lucie Pluschke, "The Water–Food–Energy Nexus – Realising a New Paradigm," *Journal of Hydrology* 533 (February 2-16): 533–540, https://doi.org/10.1016/j.jhydrol.2015.12.033.
[8] "Water, Food and Energy," UN Water, accessed December 17, 2022, https://www.unwater.org/water-facts/water-food-and-energy.

of historical understanding, the second chapter, *Oil and Development in the UAE*, contextualizes this research by describing the history of the UAE while focusing on the role of oil in the development of the state. In the remaining chapters, I analyze the political-ecological metabolisms of desalination, solar energy production, and land grabs, revealing the interconnectedness of society and nature. In the conclusion, I reflect on the findings of this study, discuss the implications and limitations thereof, and make suggestions for further research.

Chapter 1. Agency and the Middle Eastern Environment

1.1. Introduction

This chapter outlines the theoretical framework of this thesis and provides a literature review, situating this research within the broader scholarly discourse. The first section delineates the theoretical basis of this thesis, exploring the concept of the social metabolism through a political ecology lens. Building on this framework, I formulate my hypotheses. The second section evaluates the existing scholarship on human-environment relations in the Middle East. In light of the extensive scope of the literature review, I focus on the most prominent arguments within the several bodies of works. Finally, a gap in the literature is identified, emphasizing the academic relevance of this thesis.

1.2. Theoretical framework

This thesis employs a framework based on the social metabolism. This concept was developed most notably by Marina Fischer-Kowalski and John Bellamy Foster, who identify the roots of the social metabolism in Marx's work. As Foster explains, Marx identified a "'rift' in the 'metabolic interaction between man and the earth.'" At the heart of the theoretical construct of this 'metabolic rift' lies the social metabolism, which delineates the complex, interdependent process connecting society and nature.[9] This notion implies a "material exchange relation between man and nature, a mutual interdependence beyond the widespread simple idea of man 'utilizing nature.'"[10]

The social metabolism concept offers a useful lens through which to analyze the role of natural resources in strategies employed to deal with environmental challenges, as it encompasses the entire resource cycle – the process through which social systems derive energetic and material resources from the environment, transmute them into other forms within the economic realm, employ them for other functions, and, ultimately, discharge them back into nature in altered form.[11] Applying this concept to this study, the employment of energetic and material resources for other uses represents a particular strategy taken to address an environmental challenge. The role of natural resources, then, can be understood through the process of their extraction and their subsequent employment within this metabolism.

However, the classic framework of the social metabolism is not sufficient in analyzing the management of environmental challenges for two reasons. The classic social metabolism

[9] John Bellamy Foster, "Marx's Theory of Metabolic Rift: Classical Foundations for Environmental Sociology," *American Journal of Sociology* 105, no. 2 (September 1999): 378–383, https://doi.org/10.1086/210315.
[10] Marina Fischer-Kowalski, "Society's Metabolism: The Intellectual History of Materials Flow Analysis, Part I, 1860-1970," *Journal of Industrial Ecology* 2, no. 1 (January 1998): 64, https://doi.org/10.1162/jiec.1998.2.1.61.
[11] Karl-Heinz Erb et al., "Beyond Inputs and Outputs: Opening the Black-Box of Land-Use Intensity," in *Social Ecology*, eds. Helmut Haberl et al. (Berlin: Springer, 2016): 105–106.

is often understood in relation to the organization of the labor process and primarily focuses on input and output flows.[12] Therefore, it risks omitting broader social, political, and economic variables but also practical factors that mediate the exchanges between society and nature. Furthermore, as Mindi Schneider and Philip McMichael have argued, the concept builds on a static notion about the environment without consideration for the dynamic and cyclic nature of ecology.[13] This is problematic since environmental challenges evolve and transform over time, affecting the functioning of the metabolism.

These shortcomings are addressed by applying political-ecological theory to the social metabolism. First, this allows for a fuller account of social metabolic outcomes by considering multiple dimensions. Overall, political ecology explains the condition and change of social and environmental systems while explicitly considering power relations. The field reveals that ecological systems are connected to political, social, and economic processes. Specifically, I will draw on what Paul Robbins terms the 'political objects and actors thesis,' as this research seeks to explain sociopolitical processes (i.e., the metabolisms of environmental management strategies).[14] The thesis explains sociopolitical conditions by focusing on the material characteristics of nature and its components and examines how these are intertwined with society. This approach maintains that, as these material characteristics interact with human actors, their roles and significance are transformed. Individuals, societies, and institutions participate in the networks that emerge from these human-environment interactions, asserting influence over these networks. While nature may at times be pliant with society, it can also present barriers, for instance in the shape of environmental challenges. This uncooperative materiality of the environment is theorized to shape political and economic outcomes as well as governance systems. This general focus on the political is particularly appropriate in the context of this research, as politics are fundamentally entrenched in environmental management.[15]

Second, the social metabolism's static nature can be resolved by drawing on Diana Davis' historical approach to political ecology. As Davis argues, historical analysis is crucial in political ecology analyses of human-environment relations. She maintains "that it is only with a sophisticated and critical understanding of the historical development of landscapes/environments, [and] of social relations (…) that we can reveal the hidden relations of power often at play in the questions studied by political ecologists." As such, she considers the historical development of nature and social, economic, and political forces to affect the

[12] Fischer-Kowalski, "Society's Metabolism," 64; Schneider and McMichael, 472.
[13] Mindi Schneider and Philip McMichael, "Deepening, and repairing, the metabolic rift," *Journal of Peasant Studies* 37, no. 3 (July 2010): 481–482, https://doi.org/10.1080/03066150.2010.494371.
[14] Robbins, *Political Ecology*, 19–21.
[15] Ibid., 231–235.

social metabolism.[16] Thus, including historical factors in the social metabolism framework, resolves the immobility of the classic social metabolism.

In applying political ecology to the social metabolism, this thesis diverges from classic metabolism approaches, establishing a 'political-ecological metabolism' framework. This framework enables the recognition of a broad array of interrelated factors operating at different levels that impact the functioning of the metabolism, and vice versa, with a specific emphasis on power dynamics. Illustrated in Figure 1, the political-ecological metabolism highlights mutual interdependencies. Social, economic, political, and environmental factors affect the social metabolic process, while the functioning of this process also influences reality outside the metabolism. This cyclic mechanism allows for continuous transformation of the metabolism and its surroundings.

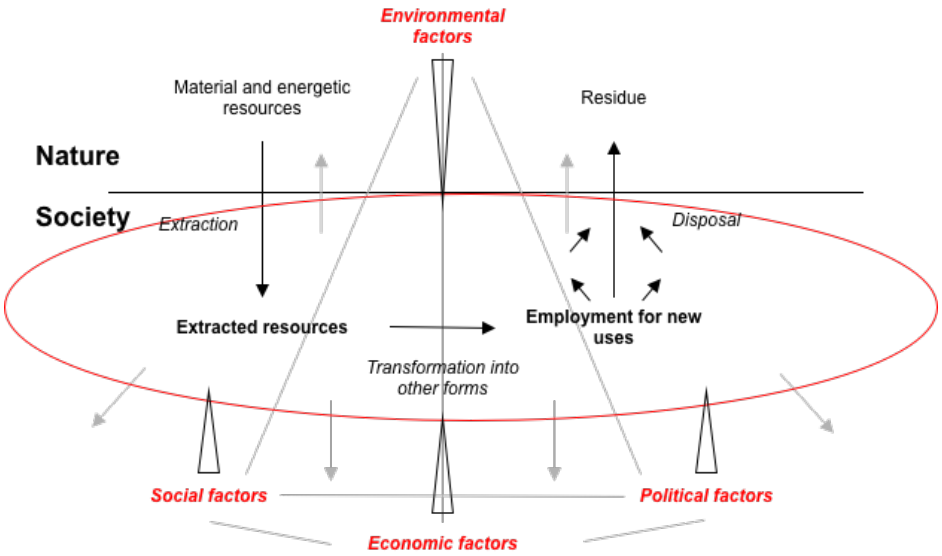

Figure 1. The political-ecological metabolism.

Based on the theoretical framework presented here, I formulate four hypotheses. Building on political ecology literature, I hypothesize, first, that natural resources, through complex social, economic, political, and environmental processes that have changed over time, have enabled the UAE to manage environmental challenges effectively. Second, in light of political ecology's emphasis on power relations and given the UAE's abundant oil reserves, I hypothesize that oil is central to dealing with environmental challenges by granting the UAE ruling elite the necessary political and economic power to set certain approaches to environmental challenges in motion. In addition, as the social metabolism and political ecology scholarship stress society's and nature's engagement in mutual exchanges, I hypothesize, third, that the ways in which the UAE has managed environmental challenges have also, in

[16] Diana Davis, "Historical Approaches to Political Ecology," in *The Routledge Handbook of Political Ecology*, eds. Tommy Perreault, Gavin Bridge, and James McCarthy (London: Routledge, 2015): 263–264.

turn, forged its power. Fourth, underlining the overall interconnectedness of socio-environmental networks, I hypothesize that the metabolisms of water, energy, and food strategies will not only show that society and the environment interact but also that the metabolisms of these vital resources engage with each other.

1.3. Literature review

In academic literature, human-environment relations in the Middle East are generally considered to be a one-way street, the former being constrained by the latter. The environment is presented as a challenge that its inhabitants seem to be unable to overcome. This notion is evident in the political science literature on conflict onset. The link between environmental scarcity and conflict has often been explored by scholars and is dominant in analyses of the Middle East. The neo-Malthusian narrative that is fundamental to this idea theorizes that ever-growing populations and a decreasing pool of resources will lead to increased competition. The distributional conflicts that arise as a result of this competition are thought to result in violent clashes.[17] Building on this line of thought, Homer-Dixon, in his influential work *Environment, Scarcity, and Violence*, argues that environmental scarcities set in motion (interconnected) processes of migration, constrained economic productivity, and social segmentation and weakened institutions. These processes, in turn, are argued to be instigators of group-identity conflicts, coup d'états, or insurgencies.[18] Scholars have also proposed other causal mechanisms to link environmental scarcity to conflict, such as adding food insecurity as an intermediary variable. In light of conventional perceptions of the region's scarce nature, overpopulation, and instability, such theories are frequently applied to reality in the Middle East.[19]

The same neo-Malthusian logic has also been applied to interstate conflict, predominantly while referring to 'water wars' in the region.[20] Following this logic, when national water scarcity is high, states can begin to view water as a matter of national security. Peter Gleick – illustratively – notes that the Middle East, in particular, has been historically prone to international water conflict, mentioning its "arid" nature and "overpopulated" regions.[21]

[17] Hoffmann, "Environmental determinism," 94–104; Idean Salehyan and Cullen Hendrix, "Climate Shocks and Political Violence," *Global Environmental Change: Human and Policy Dimensions* 28, (September 2014): 239, https://doi.org/10.1016/j.gloenvcha.2014.07.007.
[18] Homer-Dixon, *Environment*, 134–176.
[19] Hofmann, "Environmental determinism," 95.
[20] Jason Morrissette and Douglas Borer, "Where Oil and Water Do Mix: Environmental Scarcity and Future Conflict in the Middle East and North Africa," *Parameters: Journal of the US Army War College* 34, no. 4 (Winter 2004): 86–101, https://doi.org/10.55540/0031-1723.2223.
[21] Peter Gleick, "Water as a Weapon and Casualty of Armed Conflict: A Review of Recent Water-related Violence in Iraq, Syria, and Yemen," *WIREs Water* 6, no. 4 (July/August 2019): 1–15, https://doi.org/10.1002/wat2.1351.

While arguments about the effects of environmental scarcity are at times substantiated by referring to past cases, they often serve as a warning for future hardship.[22] Indeed, neo-Malthusian thought that highlights the risk of ever-growing populations is central to Homer-Dixon's theory.[23] However, more recently, several scholars have also warned about the impact of climate change on future (international) security, sparking a new surge of interest in environmental violence.[24] Some have already suggested, for instance, that the Syrian Civil War is driven by environmental factors related to climate change.[25] Notably, this driver of future doom, again, appears to be particularly relevant in the Middle East.[26]

Furthermore, the literature on human-environment relations that focuses on fossil fuel-rich states, such as the Gulf states, suggests that Middle Eastern society is not only challenged by the ramifications of environmental scarcity but also of abundance. Scholars concerned with civil conflict have suggested that resource abundance, particularly in the form of vast oil reserves, increases the likelihood of intrastate violence in the context of the Middle East.[27] Various international relations academics have also associated oil with interstate conflict, referring to 'oil wars' such as the Iran-Iraq War and the Iraqi invasion of Kuwait.[28] The 'resource curse' thesis goes even further by suggesting that resource-abundant countries are essentially cursed. Especially when rich in natural oil resources, a state can expect harmful economic and political outcomes, such as lower democracy levels, reduced economic development, weaker institutions, corruption, and civil war.[29] Rentier State Theory (RST) similarly argues that resource-rich states with certain characteristics are more prone to economic stagnation and lower democracy levels.[30] Instead of an increased likelihood of conflict, in contrast, RST proposes higher levels of political stability for so-called rentier states.[31] This is not a pleasant stability, however, as it rather facilitates the state's authoritarianism, hindering the

[22] See, for example: Peter Gleick, "Reducing the Risks of Conflict over Fresh Water Resources in the Middle East," *Studies in Environmental Science* 58 (1994): 41–54, https://doi.org/10.1016/s0166-1116(08)71399-2.
[23] Homer-Dixon, *Environment*, 47–72.
[24] See, for example: "Jon Barnett and W. Adger. "Climate Change, Human Security and Violent Conflict," Political Geography 26, no. 6 (August 2007): 639–55, https://doi.org/10.1016/j.polgeo.2007.03.003.
[25] Hoffmann, "Environmental determinism," 94–95; Tobias Ide, "Climate War in the Middle East? Drought, the Syrian Civil War and the State of Climate-Conflict Research," *Current Climate Change Reports* 4, no. 4 (December 2018): 347–348, https://doi.org/10.1007/s40641-018-0115-0.
[26] Hoffmann, "Environmental determinism," 94–95.
[27] Axel Dreher and Merle Kreibaum, "Weapons of Choice: The Effect of Natural Resources on Terror and Insurgencies," *Journal of Peace Research* 53, no. 4 (July 2016): 539–553, https://doi.org/10.1177/0022343316634418; Peter Carey II et al., "Oil Discoveries, Civil War, and Preventive State Repression," *Journal of Peace Research* 59, no. 5 (September 2022): 648–662, https://doi.org/10.1177/00223433211047365.
[28] Emily Meierding, "Dismantling the Oil Wars Myth," *Security Studies* 25, no. 2 (2016): 258–288, https://doi.org/10.1080/09636412.2016.1171968.
[29] Benjamin Smith and David Waldner, *Rethinking the Resource Curse* (Cambridge, England: Cambridge University Press, 2021), 1–5.
[30] Benli Altunişik, "Rentier State Theory," 77–79.
[31] Uriel Abulof, "'Can't buy me legitimacy': the elusive stability of Mideast rentier regimes," *Journal of International Relations and Development* 20 (2017): 57–60, https://doi.org/10.1057/jird.2014.32.

development of its inhabitants. The hydrocarbon-rich Gulf states have frequently been analyzed through the lens of the resource curse thesis and RST in particular.[32]

What these theories have in common, from the scarcity conflict thesis to the resource curse, is that they all portray humans as being at the mercy of their hostile environment. This way of analyzing human-environment relations is what some critical scholars consider to be a form of 'environmental determinism.' The loss of human self-agency seems to be particularly relevant for the Middle East's inhabitants, as these theories are a common frame for interpreting human-environment relations in the region.[33]

Various scholars have challenged these deterministic theories for their weak empirical record. Primarily with regard to the relationship between environmental scarcity and intrastate conflict, empirical support has been rather weak.[34] The existence of 'water wars' has also been questioned, most notably by Aaron Wolf.[35] In the Middle Eastern context, Mostafa Dolatyar and Tim Gray similarly contend that water scarcity in the past did not cause interstate conflict.[36] Furthermore, the relationship between climate change and conflict has been disputed by academics.[37] For instance, in the case of the Syrian Civil War, Selby et al. demonstrate that claims about such a relationship have little merit.[38] The linkage between resource abundance and conflict has been less controversial. Nevertheless, some scholars have critiqued the notion of 'oil wars,' various effects of the resource curse, and some RST-assumptions.[39] Matthew Grey even argues that classic RST has lost its relevance in the modern-day Gulf states.[40]

Political ecologists have critiqued environmental determinism more fundamentally. This field demonstrates the connectedness between social, economic, political, and environmental variables at various levels, arguing that society and nature are intertwined. In

---

[32] Hofmann, "Environmental determinism," 97–98. See, for example: Matthew Grey, "A Theory of "Late Rentierism" in the Arab States of the Gulf," *CIRS Occasional Paper* 7 (2011): 1–2, http://dx.doi.org/10.2139/ssrn.2825905.
[33] Hoffmann, "Environmental determinism," 95–98.
[34] Mildner, Lauster and, Wodni, "Scarcity and Abundance," 157–162; Vally Koubi et al., "Do Natural Resources Matter for Interstate and Intrastate Armed Conflict?" *Journal of Peace Research* 51, no. 2 (March 2014): 227–228, https://doi.org/10.1177/0022343313493455.
[35] Aaron Wolf, ""Water Wars" and Water Reality: Conflict and cooperation along international waterways," In *Environmental Change, Adaptation, and Security*, ed. S. C. Lonergan (Dordrecht: Springer, 1999), 251–265.
[36] Mostafa Dolatyar and Tim Gray. "The Politics of Water Scarcity in the Middle East," *Environmental Politics* 9, no. 3 (2000): 65–88, https://doi.org/10.1080/09644010008414538.
[37] Vally Koubi, "Climate Change and Conflict," *Annual Review of Political Science* 22, no. 1 (May 2019): 343–360, https://doi.org/10.1146/annurev-polisci-050317-070830.
[38] Jan Selby et al., "Climate Change and the Syrian Civil War Revisited," *Political Geography* 60, (September 2017): 232–244, https://doi.org/10.1016/j.polgeo.2017.05.007.
[39] See, for example: Abulof, "Legitimacy," 55–79; Emily Meierding, *The Oil Wars Myth: Petroleum and the Causes of International Conflict* (Ithaca: Cornell University Press, 2020); Thad Dunning, *Crude Democracy: Natural Resource Wealth and Political Regimes* (Cambridge, England: Cambridge University Press, 2009), 278–291, https://doi.org/10.1017/cbo9780511510052; Tiago de Cavalcanti, Kamiar Mohaddes, and Mehdi Raissi, "Does Oil Abundance Harm Growth?" *Applied Economics Letters* 18, no. 12 (2011): 1181–1184, https://doi.org/10.1080/13504851.2010.528356.
[40] Grey, "Late Rentierism," 1–44.

relation to environmental conflict, for instance, some political ecologists assert that such conflicts are part of larger struggles related to gender, class, and race, and vice versa.[41] The persistence of environmental deterministic notions about the Middle East in the literature is believed to be rooted in colonial ideas regarding 'native' environmental mismanagement, politicized imaginaries about overpopulation, and realities shaped by post-colonial heritages, amongst others.[42]

Some political ecology studies have previously explored the role of natural resources in environmental management in the Gulf.[43] Most notably, Toby Jones, in the context of Saudi Arabia, shows that oil has been vital to state power, engendering the consolidation of the kingdom and producing the wealth that ensured the political primacy of the ruling elite. Water is shown to be equally important to the political power of the state: its vitality assured that successful water management provided the state with substantial control over its inhabitants, while it has also been key to dominating land and food. Jones emphasizes the interconnectedness of these resources, as oil wealth permitted the expensive production of water in Saudi Arabia. Moreover, while oil wealth shaped state power, it also affected the ways in which the state engaged with water management and distribution, which, in turn, strengthened Saudi authority.[44] In contrast with environmental determinist theories, this study demonstrates a shared agency linked to both humans and nature.

Nevertheless, this body of literature is yet to offer a comprehensive analysis of the interaction between natural resources, human actors, and challenges in multiple environmental dimensions in a single case study context. Moreover, the existing political ecology literature on the Gulf has overwhelmingly focused on Saudi Arabia. This research addresses these gaps in the literature on human-environment relations by examining the role of natural resources in engaging with environmental challenges in the UAE through the analysis of the political-ecological metabolisms of water, energy, and food management strategies. In doing so, I also intervene in the broader academic debate on the placement of agency within the human-environment nexus.

[41] Robbins, *Political Ecology,* 20, 199–214.
[42] Dianna Davis, "Imperialism, Orientalism, and the Environment in the Middle East," in *Environmental Imaginaries of the Middle East*, ed. Diana Davis and Edmund Burke III (Athens, Ohio: Ohio University Press, 2011): 1–16; "Hoffmann, "Environmental determinism," 94–104.
[43] Henderson, "Land Grabs"; Jones, *Desert Kingdom*; McDonnell, "Hydrosocial Cycle"; Woertz, *Oil for Food*.
[44] Jones, *Desert Kingdom*, 3, 17, 236–239.

Chapter 2. Oil and Development in the UAE

2.1. Introduction

This chapter presents a historical overview of the development of the Emirati state. The discovery of oil deserves a central focus in this regard, as it facilitated the subsequent growth and development that shaped the UAE's contemporary social, economic, political, and environmental realities.[45] Interpreting the role of natural resources in the management of environmental challenges, thus, requires a proper understanding of the history of oil and development in the Gulf state. This historical approach is particularly relevant in the Middle Eastern context considering the conventional peripheral portrayal of the region, in which its sociopolitical condition has often been contextualized in relation to global processes, thereby overlooking historical and regional specificities.[46] This chapter begins by discussing the pre-oil era before turning to the subsequent development and growth of the Emirati state.

2.2. The foundations of post-oil developments

Not long after the first oil exports, and in the wake of British withdrawal from the region, on 2 December 1971, the United Arab Emirates came into being with an agreement reached between the rules of six emirates in the lower Gulf (Abu Dhabi, Ajman, Dubai, Fujairah, Sharjah, and Umm al-Quwain). The Emirate of Ra's al-Khaimah acceded to the newly formed federation three months later.[47] The establishment of the federation, however, can hardly be regarded as the starting point for analyses of the history of oil in the UAE, nor can the actual discovery of oil in the Emirate of Abu Dhabi more than a decade before.[48]

In fact, it makes little sense to describe the history of the lower Gulf in terms of a pre-oil post-oil binary, for many of the post-oil developments were shaped or set in motion by earlier processes. Before the extraction of natural resources became the principal economic activity, the economy of the lower Gulf had long relied on pearl hunting, facilitated by its rich seas. This reliance on the export of a single primary product resembles the later dependency on oil and gas. However, many successful men in the pearl business did not diversify their interests, making the economy exceptionally vulnerable to external market forces. Although speculative, it was periods of economic depression, such as during the 1930s, exacerbated

---

[45] Daniele Schilirò, "Diversification and Development of the United Arab Emirates' Economy," *Journal of Applied Economic Sciences* 24 (August 2013): 228, https://www.ceeol.com/search/article-detail?id=13331.
[46] Henderson, "Land Grabs," 265.
[47] Christopher Davidson, *The United Arab Emirates: A Study in Survival* (Boulder, Colorado: Lynne Rienner Publishers, 2005): 49–50; "History," Embassy of the United Arab Emirates, Washington DC, accessed April 1, 2023, https://www.uae-embassy.org/discover-uae/history#:~:text=An%20agreement%20was%20reached%20between,established%20on%20December%202,%201971.
[48] Ibrahim Abed and Peter Hellyer, eds., *United Arab Emirates: A New Perspective* (London: Trident Press, 2001), 232.

by a lack of diversification, that possibly encouraged economic diversification during the oil era.[49] Furthermore, the allure of the pearling industry's potential for significant profits and the entrepreneurial opportunities that arose enticed many foreigners to venture into the lower Gulf region. The high levels of expats during this time mirror the contemporary demographic composition, albeit on a smaller scale.[50]

Increasing British involvement in the region since the beginning of the pearling era in the early 20th century gave rise to centralization, consolidation, and extension of the ruling sheikhs' power. The treaties that the British signed with local rules were a source of strength for the ruling elite, given the substantial power of the British Empire and its interest in maintaining the status quo.[51] Furthermore, the British provided the sheikhs with financial power by solidifying rentier structures. Whereas local rulers already had derived rents from issuing fishing licenses and booty from raids, these rents were negligible compared to the generous air landing fees the British began to pay. The oil exploration concessions during the 1920s and 1930s, which were proposed in anticipation of the possible discovery of oil and prohibited the rulers from considering oil concessions not supported by the British government, were even more lucrative were.[52] These pre-oil discovery concessions clearly illustrate the blurring of the pre-oil post-war binary. With these significant rents at their disposal, local rulers were able to distribute wealth directly to their people without relying on taxation. These rentier relationships continue to empower the political elite in the UAE. In the early 20th century, the British also furthered power consolidation, centralization, and extension on a larger scale by encouraging cooperation between the emirates.[53] These processes continued and intensified well into the remainder of the 20th century and, as will be argued, have shaped the state's capacity to engage with environmental challenges.

2.3. Oil and the development of state power

Although the pre-oil developments were significant in their contribution to the contemporary reality of the UAE, the discovery of oil in 1958, nevertheless, was undeniably a turning point in the development of the emirates.[54] In the decades thereafter, the oil business boomed: The years after the first exports in 1962 saw a staggering rise in oil production of more than 200% per year. However, oil exports did not rise to astronomic proportions until after the formation

[49] Davidson, *The United Arab Emirates*, 5–8.
[50] Ibid., 12–13.
[51] Ibid., 29–32
[52] Ibid., 34–37.
[53] Ibid., 41–50
[54] Abdullah Omran Taryam, *The Establishment of the United Arab Emirates: 1950-85* (London: Croom Helm, 1987): 46; Abed and Hellyer, *United Arab Emirates*, 231–234.

of the UAE in 1971.[55] These developments brought about new processes while altering and accelerating those that were already set in motion. This had profound consequences, first, for the development state power.

The discovery of oil solidified processes of power consolidation and centralization. The most obvious and direct effect of oil production was a tremendous increase in the wealth of the ruling elite, as oil revenues flowed directly to the ruling family. These families employed their oil money to considerably strengthen and extend the existing rentier structures through growing neo-patrimonial networks. Conjointly, it was imperative for the elites to institutionalize these networks to ensure the continuation of rentier relationships. As such, institutionalization has been a key development in the early years of petroleum exports, as well as thereafter, primarily in the form of bureaucratic institutions.[56] The ruling elite, building on the growing rentier networks embedded within the newly established institutions, were able to carefully distribute their accrued wealth and prestigious positions within these networks to solidify their power. These developments effectively consolidated and legitimized the power of the ruling elite. Furthermore, they strengthened and centralized state power, as the institutionalized, distributive state emerged as the principal economic actor.[57]

Meanwhile, oil's financial and strategic value also contributed to the intensification and centralization of state power. Although the British push for cooperation and their subsequent withdrawal can be regarded as major factors in the formation of the federation, oil played a meaningful part in two ways. First, it enabled a greater budget for development projects in the poorer emirates, strengthening the ties between the emirates. Second, the discovery of oil increased British interest in regional stability, and regional cooperation was seen as a viable remedy. Most local rulers also agreed that further cooperation was increasingly necessary.[58] After the creation of the federation, the Western desire for regional stability continued to strengthen the state. Most critical components of UAE's oil and gas industries are 40% to 49% owned by European, Japanese, or United States oil companies. The allowance of foreign stakes in the state's key economic sector has led to military reassurances of Western powers in the case of a breach of national sovereignty.[59] Thus, it was for a large part the foreign concern with oil reserves that encouraged cooperation between the emirates and strengthened the state's security after the establishment of the federation, contributing to power centralization and expansion.

[55] Davidson, *The United Arab Emirates*, 120.
[56] Ibid., 84–89
[57] Ibid., 89.
[58] Ibid., 43–47.
[59] Ibid., 92–97

Still, while centralization indeed increased notably, it is worth mentioning that the individual emirates enjoyed a rather high amount of responsibility and independence. After 1971, the mandate over natural resource management came to lie exclusively with the individual emirates, providing them with considerable autonomous power and resources. This allowed the various emirates to follow different development paths.[60] Therefore, in this sense, natural resources arguably also contributed to the upholding of a relatively high degree of individual emirate authority.

Overall, however, the result of these developments was a stable, distributive state financed by oil with a heavily increased level of political and economic power. The export of oil played a significant role in these mechanisms, as it intensified connected processes of power consolidation and centralization that were already evident during the pre-oil era. This development of state power allowed for socioeconomic progress, which in turn also reinforced state power, as will be shown in the next section. Moreover, the following chapters will demonstrate that these processes intervened in the metabolisms of environmental management strategies. These observations indicate a strong connection between society and nature.

2.4. Oil, socioeconomic development, and diversification

Besides developing state power, the UAE pursued socioeconomic development in several areas, facilitated by the economic resources gained from hydrocarbon exports.[61] Regarding social development, for instance, education was given top priority after its formation. A sophisticated, free system of education and various educational institutions were established in the 1970s and 1980s.[62] Consequently, the Emirati educational system is now one of the most developed in the Middle East.[63] In relation to healthcare, the UAE's efforts to advance the provision of competent and essential health services, as well as their expansion across diverse regions and demographics, were equally impressive. The number of hospitals, medical centers, and hospital beds has risen steadily to meet the demands of a growing population, and as early as 1995, 99% of the population had access to healthcare services. Furthermore, social security laws were passed that ensured the generous provision of social

[60] McDonnell, "Hydrosocial Cycle," 227.
[61] Omar Saif, Toufic Mezher and Hassan Arafat, "Water security in the GCC countries: challenges and opportunities," *Journal of Environmental Studies and Sciences* 4, no. 4 (December 2014): 331, https://doi.org/10.1007/s13412-014-0178-8.
[62] Taryam, *The Establishment*, 261–265
[63] Davidson, *The United Arab Emirates*, 139–143.

benefits to certain disadvantaged groups.[64] These developments fostered socioeconomic development but also partly served to empower the state and reinforce rentier networks.

Additionally, the UAE skillfully employed its oil wealth to pursue economic growth beyond the oil sector. The necessity for economic diversification was highlighted by the high dependence on foreign labor and technology. Furthermore, the oil price fluctuations of the 1980s and, arguably, earlier experiences with economic depression during the pearling era contributed to the early commitment to diversification.[65] As such, the UAE initiated improvements in telecommunication services and the physical infrastructure, building a first-class road network and several seaports.[66] Moreover, fruitful efforts were made to improve the provision of electricity and water,[67] which will be discussed further in Chapters 3 and 4. Additionally, a capable manufacturing industry was established to cope with the demands of infrastructural projects and a growing population.[68] Diversification has also occurred through large investments in the agricultural sector, reducing the reliance on food imports, which will be further described in Chapter 5.[69] In terms of export-oriented diversification (EOI), Dubai, for example, became involved in aluminum export, which began to account for a significant proportion of Dubai's non-oil exports in the 1990s and 2000s. The post-1970 development of the natural gas sector can also be regarded as part of the diversification project; the export of gas, although less lucrative than the oil exports, became the major driver of EOI in the UAE.[70] In more recent years, moreover, the UAE has also engaged in the diversification of the domestic energy mix through renewable energy, reducing its dependency on oil exports.[71] This effort, as well as its drivers and shaping forces, will be further detailed in Chapter 4. The commerce and tourist sectors also became important components of the diversification strategy, most notably in Dubai, where tourist numbers have drastically surged. Whereas the emirate hosted 400,000 tourists in 1975, almost 17 million visited in 2018.[72] These developments successfully diversified substantial portions of the UAE's economy. The value and volume of international non-oil trade have subsequently increased in all emirates, with a

[64] Abed and Hellyer, *United Arab Emirates*, 256–258; Davidson, *The United Arab Emirates*, 139–140; Taryam, *The Establishment*, 265–268.
[65] Davidson, *The United Arab Emirates*, 119–123; 5–8.
[66] Ibid., 137–139; Taryam, *The Establishment*, 271–273.
[67] Taryam, *The Establishment*, 271–273.
[68] Abed and Hellyer, *United Arab Emirates*, 261–264.
[69] Davidson, *The United Arab Emirates*, 128-129.
[70] Ibid., 123–127.
[71] "UAE Energy Diversification," Embassy of the United Arab Emirates, Washington DC, accessed April 21, 2023, https://www.uae-embassy.org/discover-uae/climate-and-energy/uae-energy-diversification.
[72] "Dubai Tourism Statistics 2023," Global Media Insight, March 13, 2023, https://www.globalmediainsight.com/blog/dubai-tourism-statistics/.

striking increase of more than 5,000% in 2022 compared to 1975.[73] At present, the non-oil industries account for 70% of the Emirati GDP and continue to grow.[74]

This socioeconomic progress, engendered by the petroleum exports, has profoundly impacted the UAE. Firstly, it has resulted in rapid population growth, primarily driven by expat workers who played a vital role in the socioeconomic development projects.[75] In addition, the UAE has witnessed a rise in living standards and concurrent urbanization trends.[76] Moreover, these developments have strengthened power consolidation processes by directly providing socioeconomic benefits and solidifying the state's financial power. As subsequent chapters will argue, these processes play a fundamental role in shaping environmental management strategies, underlining the significance and mutual exchanges of society-nature interactions.

2.5. Conclusion

This chapter has provided a historical overview of the development of the Emirati state with a specific focus on the role of oil. This has revealed that fossil fuel resources are entrenched in the development of the state. Although many processes that define the development of the UAE were already set in motion in the pre-oil era, oil played a vital part by altering and accelerating these processes. The value of fossil fuel resources was key in the distribution of rent, emirate cooperation, and ensuring international security, which has solidified processes of power consolidation and centralization. Meanwhile, their economic profits were employed for socioeconomic development and diversification, which, in turn, have transformed UAE society in multiple ways. These developments and processes laid the groundwork for the state's dealing with environmental challenges.

This chapter has discovered several relevant findings. First, by elucidating the role of natural resources in the development of the UAE, it has underlined the significance of metabolic exchanges between society and nature, the latter primarily affecting the former in this case. However, as will be discovered later, this relationship is less unidirectional in the long term. Another relevant observation is the mutually reinforcing relationship between state power and socioeconomic development, representing the transformative, cyclic nature of the political-ecological metabolism. Moreover, the central role of oil in providing the state with political and economic power indicates initial support for my second hypothesis. With these

[73] Rachna Uppal, "UAE's non-oil foreign trade jumps 17% in 2022," *Reuters*, February 6, 2023, https://www.reuters.com/markets/uaes-non-oil-foreign-trade-jumps-17-2022-2023-02-06/; Issac John, "UAE's economy growth momentum set to pick up," *Khaleej Times,* December 27, 2013, https://bit.ly/3CeXCOn.
[74] Uppal, "UAE's nonoil foreign trade."
[75] Davidson, *The United Arab Emirates*, 145.
[76] Ahmed Murad, Hind Al Nuaimi, and Muna Al Hammadi, "Comprehensive Assessment of Water Resources in the United Arab Emirates (UAE)," *Water Resources Management* 21 (2007): 1459, https://doi.org/10.1007/s11269-006-9093-4; McDonnell, "Hydrosocial Cycle," 231–232.

insights in mind, the next chapters will explore the role of natural resources in UAE environmental management strategies in relation to water, food, and energy.

Chapter 3. Water in the UAE: Desalination

3.1. Introduction

In this chapter, I study the political-ecological metabolism of desalination in the UAE. The country's increasingly scarce natural water supply and its steadily growing demand have presented significant challenges to the state regarding domestic water provision.[77] Desalination, the practice of desalinating sea water to produce fresh water, emerged as a dominant strategy to overcome this water challenge.[78] This chapter begins by addressing the issue of natural water scarcity and the development of water management in the UAE in order to comprehensively understand and contextualize desalination practice. Subsequently, it delves into exploring the metabolic processes of desalination. Finally, this chapter traces the role of natural resources in shaping desalination in the UAE. It is demonstrated that natural resources are entangled in the practice of desalination via mutual exchanges with its social, economic, political, and natural environment.

3.2. The water challenge and the development of water management

The UAE has faced a range of environmental challenges that require unconventional water management strategies. Located in an arid region, the Emirati climate is characterized by high temperatures, levels of humidity and evaporation rates, and low and irregular rainfall.[79] The availability of water resources in the UAE is profoundly shaped by this arid climate: High evaporation reduces surface water availability, while scarce rainfall negatively affects both surface water and groundwater levels. As a result, surface water resources are largely absent. Groundwater, on the other hand, can be found more commonly in the UAE and has historically served as the primary source of water supply.[80] However, freshwater demand has proliferated since the socioeconomic development in the state. Simultaneously, both the quality and quantity of the already limited natural supply have declined due to the overpumping of groundwater. Consequently, the emirates have needed to adopt new water management strategies to enhance the water availability for their population.[81]

---

[77] Abdulrahman Alsharhan and Zeinelabidin Rizk, *Water Resources and Integrated Management of the United Arab Emirates* (Springer: Berlin, 2020): 271.
[78] "Water," U.AE, accessed April 6, 2023, https://u.ae/en/information-and-services/environment-and-energy/water-and-energy/water-.
[79] Suzan Shahin and Mohammed Salem, "The Challenges of Water Scarcity and the Future of Food Security in the United Arab Emirates (UAE)," *Natural Resources and Conservation* 3, no. 1 (2015): 1, https://doi.org/10.13189/nrc.2015.030101; Sylvia Szabo, "The Water Challenge in the UAE," *Dubai School of Government Policy Brief*, no. 29 (December 2011): 3, https://eprints.soton.ac.uk/376548/1/DSG%2520Policy%2520Brief%252029%2520English.pdf.
[80] Murad, Al Nuaimi, and Al Hammadi, "Water Resources," 1449–14450.
[81] Abdulrahman Alsharhan and Zeinelabidin Rizk, *Water Resources and Integrated Management of the United Arab Emirates* (Springer: Berlin, 2020): 456.

Accordingly, water management in the UAE has fundamentally transformed over time; from an exclusive dependency on natural water supplies to an increasing reliance on unconventional water sources. Traditionally, the water supply for consumption purposes and economic activities was dependent on wells that drew from groundwater aquifers.[82] However, a rapidly rising demand necessitated new methods of water production to be implemented soon after the first oil exports. The first desalination plant was constructed in Abu Dhabi in 1960 to this end. However, it was not until the 1970s that desalination systems grew in number and size.[83] By 1992, desalination facilities had been installed in each emirate, and currently roughly 70 desalination plants are operative in the entire state.[84] As such, the technology has emerged as the second largest source of water in the UAE today after groundwater, comprising around 24% of its water resources.[85] In terms of potable water, desalination has even become the main contributor.[86] Another, less prominent method that was developed is the treatment of wastewater, which is primarily employed for forestry and landscaping practices. Since its emergence in the early 1970s, the role of treated sewage water in Emirati water management strategies has become increasingly meaningful: In 2015, treated wastewater accounted for about 6% of total water resources in the UAE. [87] In more recent years, cloud seeding, a technology to stimulate and accelerate the condensation process in clouds, has been introduced to increase the Emirati water supply. However, its contribution to the overall water supply is still limited, and its future applicability is yet unclear.[88] In sum, these strategies have mitigated the UAE's water challenge by applying unconventional methods of water production to sustain the increasing domestic water demand.

The emergence of these strategies was concomitant with an increased role of the state in water management, corresponding with broader power centralization trends in the UAE. After the formation of the UAE, natural resources became the property of each emirate, giving the emirates primary responsibility over water management.[89] However, the state gradually became more involved. In 1975, a supreme committee was formed to draft legislation and

[82] McDonnell, "Hydrosocial cycle," 227.
[83] Hanif Sultan, "Desalination Plants in the Emirate of Abu Dhabi," in *History, Development and Management of Water Resources – Volume II*, ed. International Editorial Board (Oxford: EOLSS Publishers, 2010): 158.
[84] Murad, Al Nuaimi, and Al Hammadi, "Water Resources," 1450, 1457.
[85] Shahin and Salem, "Water Scarcity," 2.
[86] "Water."
[87] Murad, Al Nuaimi, and Al Hammadi, "Water Resources," 1454–1458; Mohamed Dawoud, Osama Sallam, and Mahmoud Abdelfattah, "Treated wastewater management and reuse in arid regions: Abu Dhabi case study," *The 10th Gulf water conference, Doha, Qatar* (2012): 732–752, https://www.researchgate.net/publication/259182543_Treated_Wastewater_Management_and_Reuse_in_Arid_Regions_Abu_Dhabi_Case_Study; Shahin and Salem, "Water Scarcity," 2.
[88] Abir Ahmar, "Parched UAE turns to science to squeeze more rainfall from clouds," *Reuters*, August 30, 2022, https://www.reuters.com/world/middle-east/parched-uae-turns-science-squeeze-more-rainfall-clouds-2022-08-30/.
[89] McDonnell, "Hydrosocial cycle," 227.

regulation in the environmental field. The committee was replaced with the Federal Environmental Agency in 1993, which worked on a federal plan for environmental action on water security. The 2006 establishment of the Ministry of Environment and Water marked a new stage in UAE water management, signaling growing attention to water-related issues.[90] 2017 saw the most recent development in this growing involvement of the federal state, as the country launched the 'UAE Water Security Strategy 2036.'[91] On the other hand, although centralization has indeed increased, the emirates remain autonomous in terms of resource management and have consequently dealt with water management slightly differently.[92]

With desalination as an essential component, the water strategy of the emirates has proven effective. Currently, 100% of the UAE population has access to safe drinking water.[93] Moreover, the UAE is able to sustain a per capita water footprint of more than double the world average despite growing demand.[94] On the other hand, pressure on water provision in the UAE remains. The depletion of groundwater resources is still on the rise due to overpumping, for instance.[95] Some studies even warn that the state could run out of groundwater resources as soon as 2030.[96] In response, the UAE has pushed for further improvements in freshwater provision by increasing centralization and coordination in the area of water management, amongst others.[97]

3.3. The desalination process

Desalination in the UAE directly relies on its access to natural resources in the shape of natural saline water. As such, most Emirati desalination plants are located along coastal lines. Seawater is typically extracted from the Arabian Gulf or the Gulf of Oman using an offshore intake structure consisting of large pumps or intake pipes. The seawater is then transported to a nearby pretreatment facility through a connected pipeline. At the pretreatment facility, the saline water undergoes a series of processes to remove impurities and contaminants. After this procedure, the pretreated water enters the desalination plant, which is usually located on the same site.[98] After the desalination process and a post-treatment procedure, the water is

[90] Alsharhan and Rizk, *Water Resources*, 724-754; "About the Ministry," MOCCAE, accessed April 11, 2023, https://www.moccae.gov.ae/en/about-ministry/about-the-ministry.aspx.
[91] "The UAE Water Security Strategy 2036," U.AE, accessed April 11, 2023, https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/the-uae-water-security-strategy-2036
[92] McDonnell, "Hydrosocial cycle," 227.
[93] Waleed Zubari, "Water Security in the GCC Countries," in *Water and Food Security in the Arabian Gulf*, ed. Markaz al-Imārāt lil-Dirāsāt wa-al-Buḥūth al-Istirātījīyah (Abu Dhabi: ECSSR, 2013), 84–87.
[94] Saif, Mezher and Arafat, "Water security," 333.
[95] Murad, Al Nuaimi, and Al Hammadi, "Water Resources," 1453–1454.
[96] Shahin and Salem, "Water Scarcity," 3.
[97] "Water Security Strategy."
[98] Alsharhan and Rizk, *Water Resouces*, 458; Emanuelle Landais, "Desalination: Facts and procedures," *Gulf News*, June 15, 2009, https://gulfnews.com/uae/environment/desalination-facts-and-procedures-1.72059; "How to

distributed through a network of pipes to citizens and companies, directly or indirectly, via service points.[99]

The UAE's environment and several technical advantages have caused desalination facilities in the country to predominantly apply thermal technologies through multi-stage flash (MSF) procedures.[100] These thermal-based systems are preferred considering their cogeneration potential, allowing both electricity and energy to be produced from the same plant. Moreover, they have proven to withstand the hot and humid climate in the UAE.[101] In addition, the Gulf seawater's high salinity and turbidity, along with its marine organism presence, have resulted in high pretreatment costs for alternative, non-thermal desalination technologies.[102] Despite its relatively high energy consumption, MSF dominates the desalination market in the UAE, comprising approximately 75% of desalinated water production. This is due to the inexpensiveness of energy in the UAE as well as the good reliability and large capacity of MSF plants. Another thermal technology, multiple-effect distillation (MED), is also employed in the country, although on a much smaller scale. Meanwhile, improvements in reverse osmosis (RO) procedures have led to a growing share of RO in total desalination production, now accounting for about 19% of desalinated water.[103]

Additionally, the UAE is directly dependent on natural resources for powering desalination plants. Desalinating water, especially through MSF, is characterized by high energy demand, which is primarily met by employing the country's natural gas reserves.[104] Besides employing its own natural gas resources to power the plants, the UAE also utilizes gas imported from Qatar, as its natural gas reserves are insufficient to meet the high energy demand. Also, the particular sulfide composition of UAE gas complicates its employment for desalination purposes.[105] In this light, some emirates – especially Abu Dhabi and Dubai – have also begun to explore the powering of RO using solar energy, indicating the significance of another natural resource in the desalination process.[106]

Create a Desalination Pipeline System," *AgruAmerica*, accessed April 12, 2023, https://agruamerica.com/desalination-pipeline-system/; "Desal Proces," Seawater Desalination, San Diego County Water Authority, accessed April 12, 2023, https://www.sdcwa.org/your-water/local-water-supplies/seawater-desalination/.

[99] Henry Fountain, "The World Can Make More Water From the Sea, but at What Cost?" *New York Times,* October 25, 2019, https://www.nytimes.com/2019/10/22/climate/desalination-water-climate-change.html.

[100] Toufic Mezher et al., "Techno-economic assessment and environmental impacts of desalination technologies," *Desalination* 266, no 1–3 (January 2011): 263–272, https://doi.org/10.1016/j.desal.2010.08.035.

[101] McDonnell, "Hydrosocial Cycle," 227.

[102] Saif, Mezher and Arafat, "Water security," 331.

[103] Mezher et al., "Desalination technologies," 263–272; Mohammed Dawoud, "Water Security in the UAE: Challenges and Opportunies," in *Water and Food Security in the Arabian Gulf*, ed. Markaz al-Imārāt lil-Dirāsāt wa-al-Buḥūth al-Istirātījīyah (Abu Dhabi: ECSSR, 2013), 239.

[104] Mezher et al., "Desalination technologies," 264–265.

[105] McDonnell, "Hydrosocial Cycle," 229.

[106] Saltanat Berdikeeva, "Water-Scarce UAE Bets on Solar-Powered Water Desalination," *Inside Arabia*, July 20, 2019, https://insidearabia.com/water-scarce-uae-bets-on-solar-powered-water-desalination/.

Various negative externalities are associated with desalinating seawater, which has implications further down the metabolism. The high energy consumption of MSF plants, and desalination in general, is associated with high levels of greenhouse gas emissions.[107] This indirectly contributes to climate change and, thus, to the further depletion of natural water resources.[108] Furthermore, desalination plants produce brine, a by-product of the desalination process comprising concentrated saltwater and a mixture of toxic treatment chemicals.[109] In the case of plants located along the coast, brine is disposed back into the sea, negatively impacting physical, chemical, and biological aspects of marine life. The uncontrolled disposal of brine near desalination plants, on the other hand, can lead to severe depletion of groundwater sources.[110]

The operations and management of the desalination facilities, as well as the distribution of the desalinated water, are regulated at the emirate level. Despite private sector involvement in the design, construction, and operation of the plants, the responsible authorities are typically government-owned. However, the last years have seen an increased involvement in the private sector in the desalination process, spanning from full government control to public-private partnerships and concessions. Primarily in Abu Dhabi, the private sector plays a substantial role in the manufacture of desalinated water.[111]

3.4. Natural resources and shaping desalination

The influence of natural resources on the desalination process clearly illustrates the intertwining of society and nature. As per my first hypothesis, this has been evident in their facilitating role in desalination practice, via various mechanisms and in varying degrees of complexity. Most directly, natural saline water is extracted, treated, and distributed as potable water, effectively serving as a substitute for the scarcely available natural fresh water. Meanwhile, the abundance of natural gas has contributed to the feasibility of the energy-intensive practice of desalination, causing the relative inexpensiveness of domestic energy production. More specifically, the cost-effectiveness of energy has also allowed for the dominance of MSF procedures, which are particularly energy demanding.[112]

Implicitly, the application of natural gas in powering desalination facilities is also attributed to the emirates' commitment to green energy, given the relatively clean combustion

[107] Mezher et al., "Desalination technologies," 264–265.
[108] Szabo, "The Water Challenge," 3.
[109] "Desal Process"; Landais, "Desalination"; "Our company," Abu Dhabi Distribution Company, accessed April 13, 2023, https://www.addc.ae/en-US/home/Pages/AboutUs.aspx.
[110] Alsharhan and Rizk, *Water Resources*, 501.
[111] Ibidem, 15, 738, 744.
[112] Mezher et al., "Desalination technologies," 264–273.

of gas-based power generation.[113] This aligns with recent explorations regarding the employment of renewable natural resources, such as solar energy, in desalinated water production. These green ambitions are in turn connected to natural resources through hydrocarbon-related (international) economic incentives and counter-oil nation branding, which will be outlined in Chapter 4. This reveals further support for my first hypothesis.

By heightening the need for unconventional water production, factors related to supply and demand have also incentivized the shift toward desalination. First, natural resources have raised water demand in various ways. The socioeconomic progress fueled by oil exploration has led to a rapidly expanding population, improvements in living standards, and advancements in industrialization and agriculture, driving upward per capita demand.[114] Furthermore, the successful distribution of fresh water by the state has partly reinforced trends of increasing water demand; it has facilitated further social and economic growth by ensuring the provision of water for socioeconomic development projects, increasing water demand.[115] In fact, as Gökce Günel argues, it has encouraged high per capita water consumption by enabling a perception of the 'infinity of water.'[116] Günel suggests that excessive water consumption is, in part, a deliberate effort by the state rooted in colonial grievances and the powerful symbolic significance of water. In this context, natural water scarcity and the state's strive and ability to overcome this challenge can be identified as contributing sources of the high water demand in the UAE. At the same time, in terms of water supply, fossil fuels have contributed to a depletion of natural freshwater resources. To meet the growing water demand, the UAE has been overpumping groundwater resources, leading to the depletion of existing aquifers and deterioration of groundwater quality.[117] Moreover, albeit hard to quantify, the burning of Emirati hydrocarbons, both domestic and abroad, aggravates climate change, further endangering the country's natural water resources.[118] The increasing water demand coupled with the decreasing natural water supply – both affected by fossil fuels through various mechanisms – have heightened the need for desalination technologies, thus stimulating the application of desalination.[119] These processes also indicate support for my first hypothesis.

In addition, further highlighting the connectedness between society and its environment, oil has presented the UAE with the necessary financial resources and political

---

[113] Ibid.
[114] Ahmed Murad, "An Overview of Conventional and Non-Conventional Water Resources in Arid Region: Assessment and Constrains of the United Arab Emirates (UAE)," *Journal of Water Resource and Protection* 2, no. 2 (February 2010): 181–182, https://doi.org/10.4236/jwarp.2010.22020; Murad, Al Nuaimi, and Al Hammadi, "Water Resources," 1459; Saif, Mezher, and Arafat, "Water security," 333.
[115] Murad, Al Nuaimi, and Al Hammadi, "Water Resources," 1449.
[116] Gökçe Günel, "The Infinity of Water: Climate Change Adaptation in the Arabian Peninsula," *Public Culture* 28, no. 2(79) (May 2016): 292–296.
[117] Alsharhan and Rizk, *Water Resources*, 456.
[118] Szabo, "The Water Challenge," 3; Zubari, "Water Security," 93.
[119] Murad, "Water Resources," 181–182; Alsharhan and Rizk, *Water Resources*, 752.

power to realize the application of desalination. Despite the relative affordability of energy, desalination remains an expensive technology to obtain drinking water.[120] The regardless large-scale application of desalination technology in the UAE is directly linked to the wealth derived from hydrocarbon exports, which provided the emirates with ample funds to invest in its water infrastructure.[121] Natural resources have also shaped desalination in the UAE through its role in power consolidation and centralization. Indeed, the growing scarcity of natural water resources has encouraged coordination and cooperation on water issues at the federal level.[122] More broadly, however, the government's push for centralization in the area of water security through the establishment of various federal institutions can be situated within the context of overarching trends of centralization and institutionalization – engendered by fossil fuels, as discussed in Chapter 2. These observations indicate a facilitating role for oil by granting the UAE political and economic power, in line with my second hypothesis.

Furthermore, supporting my third hypothesis, successful water management has also reinforced the ruling elite's authority. As Günel emphasizes, successful water management is not only a technical achievement but also a political one. In particular, the 'infinity of water' in the UAE solidifies the state's legitimacy at the regional and domestic level, but also at the international scale, where successful management of the UAE's environment is considered a mark of progress.[123] In this light, the practice of desalination, then, is also affected by political motivations that revolve around the distribution and production of naturally scarce water resources, emphasizing the relationship between the political and the environmental.

The political-ecological metabolism of desalination also demonstrates linkages to other environmental challenges discussed in this thesis. Domestic agricultural development has been responsible for a substantial share of domestic water consumption, as will be detailed in Chapter 5, stimulating the emergence of desalination. Additionally, desalination draws heavily on energy resources, accounting for up to 9% of the country's energy consumption.[124] This, in turn, affects the energy challenge delineated in the next chapter, and as noted, has led the UAE to explore renewable energy sources for powering desalination plants. These findings are in line with my last hypothesis regarding the correspondence between various environmental challenges.

However, natural resources have also impeded water management, challenging my assumptions. For instance, the high concentrations of hydrogen sulfide that characterize significant proportions of the UAE's natural gas supply requires complex and expensive

[120] Alsharhan and Rizk, *Water Resources*, 460.
[121] Saif, Mezher, and Arafat "Water security," 331.
[122] Alsharhan and Rizk, *Water Resources*, 752.
[123] Günel, "The Infinity," 296–303.
[124] Henderson, "Land grabs," 268.

processing, which has caused the state to import supplementary gas from abroad.[125] Moreover, the rising water demand and decreasing natural water supply can also be interpreted as complicating the water challenge, besides incentivizing its solutions. These nuances contrast with the assumed enabling effect of natural resources on tackling environmental challenges.

3.5. Conclusion

The UAE has committed to the desalination of seawater to address its water challenge. The natural water scarcity in the country has been exacerbated by a concurrent rise in water demand and a decrease in supply after the discovery of oil. As such, the country turned to unconventional methods of water production, of which desalination emerged as the most prominent technology. As the chief contributor to water provision for industrial and domestic uses, desalination has impressively enhanced water security in the country.

By exploring the role of natural resources in the political-ecological metabolism of desalination, this chapter has delineated the interrelation of society and nature in desalination practice. Most directly, the availability of natural saline water and gas has enabled and shaped desalination practice. Furthermore, various complex processes that are intertwined with water- and oil-related factors have incentivized the shift towards desalination, primarily by affecting water demand and the natural water supply. These processes also highlight the changing nature of the political-ecological metabolism. Additionally, however, I find a more ambiguous role for natural resources, as they can be considered to have complicated the water challenge, although this does not necessarily contradict my central argument about the close relation between humans and nature. In line with my second hypothesis, oil has been shown to be vital in the UAE's dealing with the water challenge by offering economic and political power that was used to initiate and harmonize desalination investments. The successful management of the water challenge also reinforced the state's power, again highlighting the mutual exchanges between society and nature within the cyclic political-ecological metabolism. Last, the metabolism of desalination uncovers connections to the energy and food challenges through desalination's high energy demand and the large water consumption of the domestic agricultural sector. In sum, the political-ecological metabolism of desalination offers support for all hypotheses, with some supplementing insights, emphasizing the interconnectedness of society and nature.

[125] McDonnell, "Hydrosocial Cycle," 229.

Chapter 4. Energy in the UAE: Solar Energy

4.1. Introduction

This chapter examines the political-ecological metabolism of solar energy production. The UAE's reliance on its oil and gas reserves for domestic energy consumption has presented the state with major challenges related to energy production. In response, the UAE has begun investing in renewable energy. Solar energy, in particular, has become a key component in the country's energy strategy.[126] The first section of this chapter delineates the energy challenge in the UAE and contextualizes it by describing the development of the state's energy strategy. In the following section, the process of solar energy production is described. Thereafter, I examine how natural resources have shaped this process. In doing so, this chapter illustrates the central role of natural resources in the solar energy metabolism via various complex mechanisms and, as such, the significant interplay between society and nature, in line with the findings of Chapter 3.

4.2. The energy challenge and the development of clean energy

The UAE is confronted with several challenges in relation to energy production.[127] Natural gas is a crucial source for domestic energy production, accounting for up to 98% of power generation.[128] Meanwhile, the UAE has been facing excessively growing energy demand, driven by population growth, urbanization, rising living standards, and industrialization.[129] As a result, Emirati per capita carbon emissions are among the highest in the world.[130] These high levels of emissions have caused local air pollution and affected regional climate change, leading to environmental harm such as droughts and rising temperatures, as well as societal problems including local health issues, food insecurity, and water scarcity.[131] At the same time, the international green commitment, which is believed to lead to a future stagnation and eventual decrease in fossil fuel demand, along with the ever-approaching exhaustion of oil and gas reserves, threaten the viability of the country's fossil fuel reliance for energy

[126] "Energy Diversification."
[127] Alaeddine Mokri, Mona Ali, and Mahieddine Emziane, "Solar energy in the United Arab Emirates: A review," *Renewable and Sustainable Energy Reviews* 28 (December 2013): 342, https://doi.org/10.1016/j.rser.2013.07.038.
[128] Karen Young, *The Political Economy of Energy, Finance and Security in the United Arab Emirates* (London: Palgrave Macmillan): 92.
[129] Al-Mamaary, Kazem, and Chaichan, "Climate change," 560–561; Kazim, "Energy consumption," 427; Mokri, Ali, and Emziane, "Solar energy," 341-345.
[130] "Environmental challenges," U.AE, February 7, 2023, https://u.ae/en/information-and-services/environment-and-energy/environmental-challenges-in-the-uae; Hilal Al-Mamaary, Hussein Kazem, and Miqdam Chaichan, "Climate change: The game changer in the Gulf Cooperation Council Region," *Renewable and Sustainable Energy Reviews* 76 (September 2017): 555–556, https://doi.org/10.1016/j.rser.2017.03.048.
[131] Kazim, "Energy consumption," 435–437; "Environmental challenges"; Al-Mamaary, Kazem, and Chaichan, "Climate change," 555–556; Mari Luomi, "The International Relations of the Green Economy in the Gulf – Lessons from the UAE's State-led Energy Transition," *The Oxford Institute for Energy Studies, OIES PAPER: MEP* 12 (May 2015): 3–5, https://doi.org/10.26889/9781784670313.

production.[132] To cope with these challenges, the UAE has sought alternative methods to match energy supply and demand.

Similar to water management, the state has increasingly interfered with energy policy over time, mirroring more general developments of state centralization and power consolidation – stimulated by natural resource extraction. Still, as energy affairs are the responsibility of the individual emirates, initial steps in relation to finding unconventional energy means occurred at the emirate level. Holding the most significant wealth among the emirates, Abu Dhabi predominantly initiated renewable energy projects in the 2000s. Most notably, in 2006, the emirate founded Masdar, a company devoted to sustainability research, renewable energy production, and the building of a carbon-neutral city. Subsequently, it invested 15 billion USD in the enterprise.[133] The Dubai government initiated several small-scale renewable energy projects, whereas some wind energy initiatives were realized in the Emirate of Al Fujairah.[134] However, as the salience of the energy challenge increased, the state's intervention in the emirates' energy strategies grew as well. In 2008, the UAE began developing a nuclear energy policy, citing the need for alternative energy resources.[135] Furthermore, in 2009, the UAE unveiled a national renewable energy policy aimed at realizing a 7% share of renewable energy in the power sector by 2020.[136] The UAE also included nuclear, thermal, and renewable energy investments in a major electricity investment portfolio between 2013 and 2020.[137] Most recently, 2017 saw the launch of the 'Energy Strategy 2050,' the UAE's inaugural unified energy strategy. This strategy formulates the intention to realize a 50% share of clean and nuclear energy in the country's energy mix, investing 163 billion USD.[138] These state interventions indicate a growing role for the federal government in energy policy.

---

[132] Ayoub Kazim and T. Veziroglu, "Utilization of solar–hydrogen energy in the UAE to maintain its share in the world energy market for the 21st century," *Renewable Energy* 24, no. 2 (October 2001): 261, https://doi.org/10.1016/S0960-1481(00)00199-3; Farkhod Aminjonov, "Policy Innovations and Rationale for Sustainable Energy Transition in the UAE," *Social Science Quarterly* 101, no. 7 (December 2020): 2402, https://doi.org/10.1111/ssqu.12909; Jon Gambrell, "IMF says Gulf Arab states may deplete oil savings in 15 years," *PBS*, February 6, 2020, https://www.pbs.org/newshour/economy/imf-says-gulf-arab-states-may-deplete-oil-savings-in-15-years; M. Jamil, Farzana Ahmad, and Y. Jeon, "Renewable energy technologies adopted by the UAE: Prospects and challenges – A comprehensive overview," *Renewable and Sustainable Energy Reviews* 55 (March 2016): 1182, https://doi.org/10.1016/j.rser.2015.05.087.

[133] Young, *Energy, Finance and Security*, 83–84, 87

[134] Ibid., 89–90; Kazim, "Energy consumption," 440–441.

[135] Young, *Energy, Finance and Security,* 84–85

[136] Jamil, Ahmad, and Jeon, "Renewable energy technologies," 1183.

[137] Young, *Energy, Finance and Security,* 84.

[138] Aisha Al-Sarihi and Michael Mason, "Challenges and opportunities for climate policy integration in oil-producing countries: the case of the UAE and Oman," *Climate Policy* 20, no. 10 (2020): 1234, https://doi.org/10.1080/14693062.2020.1781036; "UAE Energy Strategy 2050," U.AE, accessed 24 April 2023, https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/uae-energy-strategy-2050.

Accordingly, the UAE and the individual emirates have made strides in the field of renewable energy production. In terms of nuclear energy, the construction of four nuclear plants in Abu Dhabi commenced in 2012, of which two are currently operative.[139] As a result, nuclear energy accounted for approximately 2% of domestic energy consumption in 2021. Solar-powered energy has been the UAE's most dominant clean energy source due to favorable solar conditions. Its contribution to the domestic energy mix has been growing recently, now accounting for about 1% of domestic energy consumption.[140] In this regard, several large projects have been developed or are under construction, particularly in Abu Dhabi and Dubai, four of which are operational at present.[141] Wind energy has been a less prominent energy source, making no significant contribution to the country's energy mix.[142]

In response to the energy challenge, the UAE is in the midst of a transition towards unconventional methods of energy production. In 2012, nuclear energy did not contribute to the domestic energy mix, while solar energy contributed less than 0.01%. These numbers rose to respectively 2.1% and 1.1% in 2021.[143] The country's ambitions are far greater, as it has reserved a significant role for solar energy in its future energy strategy. However, these ambitions are yet to materialize, while the energy challenge remains.

4.3. Solar energy production

Four major solar plants are primarily responsible for solar energy production in the UAE, concentrated in Abu Dhabi and Dubai. In 2013, the Shams 1 project was launched in Abu Dhabi, the most extensive renewable energy project at the time, with a 100 megawatts (MW) capacity.[144] The second significant project in Abu Dhabi, the Noor Abu Dhabi Solar Power Plant, began operations in 2019, providing 1 gigawatt (GW) at optimal capacity. It is among the largest solar power plants located on a single site in the world.[145] In April 2023, Abu Dhabi saw the completion of a third major solar field, the Al Dhafra Solar project near Abu Dhabi city. The plant consists of approximately 3.5 million solar panels and almost doubles the capacity

[139] "Barakah Nuclear Energy Plant," Nuclear energy, U.AE, last modified March 1, 2023, https://u.ae/en/information-and-services/environment-and-energy/water-and-energy/types-of-energy-sources/nuclear-energy.
[140] Hannah Ritchie and Max Roser, "Electricity mix," United Arab Emirates: Energy Country Profile, Our World in Data, accessed April 24, 2023, https://ourworldindata.org/energy/country/united-arab-emirates#what-sources-does-the-country-get-its-energy-from; Mohsen Salimi, Morteza Hosseinpour, and Tohid Borhani, "Analysis of Solar Energy Development Strategies for a Successful Energy Transition in the UAE," *Processes* 2022, no. 10, 1338 (July 2022): 2, https://doi.org/10.3390/pr10071338.
[141] "Solar Energy," U.AE, last modified May 17, 2022, https://u.ae/en/information-and-services/environment-and-energy/water-and-energy/types-of-energy-sources/solar-energy
[142] Ritchie and Roser, "Electricity."
[143] Ibid.
[144] "Shams," Masdar, accessed April 25, 2023, https://masdar.ae/Masdar-Clean-Energy/Projects/Shams.
[145] "Noor Abu Dhabi," EWEC, accessed April 25, 2023, https://www.ewec.ae/en/power-plants/noor-abu-dhabi.

of the Noor plant.[146] Dubai mainly relies on the Mohammad bin Rashid Al Maktoum Solar Park for its clean energy production. Initiated in 2013, the solar park is set to be completed at the end of 2023, adding another 3GW to its approximately 2GW capacity.[147] Meanwhile, several small-scale solar initiatives have also been developed, such as solar-powered desalination plants and extensive rooftop projects.[148]

As noted, the Emirati environment is conducive to solar energy production due to its favorable solar conditions. The country primarily employs photovoltaic (PV) and concentrated solar power (CSP) technologies to capture solar beams, as both have unique benefits and drawbacks in the Emirati context. The former technology generates electricity directly from sunlight through many small solar cells, while the latter creates electricity from solar heat through steam that drives an internal turbine.[149] PV production is typically associated with relatively low costs, high reliability, low maintenance, and convenient modularity. Moreover, it is best suited to handle peak demand and soiling effects, which is practical considering the UAE's high solar exposure rates and dust levels.[150] CSP, on the other hand, is beneficial for its ability to store energy cheaply, which makes its application suitable for evening peak coverage. Additionally, CSP can be better integrated with desalination systems than PV, which is useful for future low-carbon desalination plans. On the other hand, CSP technology is more water and land intensive, solely the former being potentially problematic in the UAE.[151]

While energy provision is the responsibility of the individual emirates, Abu Dhabi, enriched by the export of hydrocarbons, holds significant influence over the distribution process.[152] After the solar energy conversion process, the electricity is directed to the plant's

---

[146] "Al Dhafra Solar PV," Masdar, accessed April 25, 2023, https://masdar.ae/en/Masdar-Clean-Energy/Projects/Al-Dhafra-Solar-PV.
[147] "A History of the Solar Park," Mohammed bin Rashid Al Maktoum Solar Park, MBRSIC, accessed April 25, 2023, https://mbrsic.ae/en/about/mohammed-bin-rashid-al-maktoum-solar-park/; **"**Al Maktoum Solar Park adds another 300MW to Dubai's clean energy production," *Arabian Business*, November 1, 2022, https://www.arabianbusiness.com/industries/energy/al-maktoum-solar-park-adds-another-300mw-to-dubais-clean-energy-production; "Maktoum Solar Park's fourth and fifth phases all set to meet 2023 deadline," *Arabian Business*, August 23, 2022, https://www.arabianbusiness.com/industries/energy/maktoum-solar-parks-fourth-and-fifth-phases-all-set-to-meet-2023-deadline.
[148] Tholkappiyan Ramachandran, Abdel-Hamid Mourad and Fathalla Hamed, "A Review on Solar Energy Utilization and Projects: Development in and around the UAE," *Energies* 15, no. 10 (2022), 3754: 14, https://doi.org/10.3390/en15103754.
[149] "Shams."
[150] Ahmed Hachicha, Israa Al-Sawafta, Dhouha Ben Hamadou, "Numerical and experimental investigations of dust effect on CSP performance under United Arab Emirates weather conditions," *Renewable Energy* 143 (December 2019): 263–276, https://doi.org/10.1016/j.renene.2019.04.144; Elisa Ghirard et al., "The optimal share of PV and CSP for highly renewable power systems in the GCC region," *Renewable Energy* 179 (December 2021): 1990–1991, https://doi.org/10.1016/j.renene.2021.08.005; Ramachandran, Mourad, and Hamed, "Solar Energy Utilization," 4; Sgouris Sgouridis et al., "A sustainable energy transition strategy for the United Arab Emirates: Evaluation of options using an Integrated Energy Model," *Energy Strategy Reviews* 2, no. 1 (June 2013): 11–12, https://doi.org/10.1016/j.esr.2013.03.002.
[151] Sgouridis et al., "Energy transition strategy," 12–13.
[152] Young, *Energy, Finance and Security*, 87–90.

off-taker, usually a government agency.[153] The energy, then, is delivered to households or businesses via the national electricity network. However, the domestic transmission network is managed by the Abu Dhabi government, causing other emirates to depend on its infrastructure for energy distribution.[154]

4.4. Natural resources and shaping solar energy

Solar energy production in the UAE emphasizes the intervention of natural resources in complex processes that have enabled solar energy production, supporting my first hypothesis. In a rather direct way, first, the UAE's high annual solar energy rates have boosted solar energy production.[155] This has promoted the application of solar energy compared to alternative renewable energy sources, facilitating the UAE's management of the energy challenge.

More indirectly, natural resources have affected energy supply and demand through several processes, creating an impetus to invest in solar energy. Socioeconomic development – fostered by fossil fuel extraction – has raised energy demand, giving rise to increasing living standards, urbanization, population growth, and industrialization projects.[156] At the same time, the successful provision of cheap energy reinforced these trends. The related increasing application of desalination for water production, linked to water scarcity and fossil fuel abundance, as explained in the previous chapter, has further contributed to high energy demand in the UAE.[157] However, excessive natural resource extraction in the UAE is primarily rooted in foreign demand. In this context, the financial value of oil and gas has driven resource extraction.[158] The high energy demand – connected to factors related to natural resources and their extraction – has led to increasing degradation of the conventional energy supply.[159] Furthermore, the emirates are progressively injecting more of its gas into its oil fields to enhance the productivity of the fields in the long term, also exhausting the natural energy supply.[160] As a result of growing demand and depletion of supply, the necessity to turn to other sources of energy production has been heightened.

Natural resources also incentivized solar energy production through international political and economic factors, further supporting my first hypothesis. The UAE has sought to

[153] "A History"; "Al Dhafra Solar PV"; "Noor"; "Shams."
[154] Young, *Energy, Finance and Security*, 87–90.
[155] Salimi, Hosseinpour and, Borhani, "Solar Energy Development," 2.
[156] Al-Mamaary, Kazem, and Chaichan, "Climate change," 560–561; Mokri, Ali, and Emziane, "Solar energy," 341-345.
[157] Kazim, "Energy consumption," 433–434.
[158] Nazli Choucri, Daniel Goldsmith, and Touzic Mezher, "Renewable Energy Policy in an Oil-Export Country: The Case of the United Arab Emirates," *Renewable Energy Law and Policy Review* 1, no. 1 (2010): 78, https://www.jstor.org/stable/24324589.
[159] Jamil, Ahmad, and Jeon, "Renewable energy technologies," 1184.
[160] Young, *Energy, Finance and Security*, 92.

counter an image of natural resource reliance and high carbon emissions to strengthen its international legitimacy. This effort is underlined by the record-breaking and large-scale nature of UAE solar operations.[161] In this sense, the image of fossil fuel reliance and abundance has advanced Emirati renewable energy efforts. In terms of economic stimuli, the engagement with the solar energy sector can also be interpreted as a component of the broader diversification effort discussed in Chapter 2 – financed by oil wealth. Moreover, as noted, the international response to the effects of fossil-fuel induced climate change threatens the economic viability of relying on fossil fuel exports. Therefore, renewable energies offer an additional, future-proof source of economic income.[162] At the same time, by investing in renewable energy, the UAE preserves a greater proportion of its domestic oil and gas resources for export, which generates higher foreign exchange earnings and lowers the need for subsidies. The country's commitment to renewable energy also earns carbon credits, which are tradable on global markets.[163] Additionally, renewable energy has been relatively successful in water-power cogeneration compared to fossil fuels, effectively cutting costs.[164] These factors – that are intertwined with natural resources – have advanced solar energy efforts.

Furthermore, in line with my second hypothesis, oil has granted the UAE political and financial power, facilitating the establishment of solar energy projects. Most obviously, oil wealth has allowed the state to make significant investments in these initiatives, as with most development projects.[165] This is particularly evident in the case of Abu Dhabi, which has been able to commit to solar energy most prominently compared to other emirates due to the economic resources derived from its vast oil resources. Its resource wealth has also shaped its central position in the energy distribution process.[166] In relation to political power, the increasing state involvement in the emirates' energy strategies has been enabled by power consolidation and centralization processes, to which oil has been fundamental, as argued in Chapter 2. Advocating for renewable energy investments, the state has accelerated solar energy development in the emirates.[167]

Successes in the management of the energy challenge have also, in turn, reinforced the state's power, corresponding with my third hypothesis. The UAE's progression in relation

[161] Aminjonov, "Policy Innovations," 2400; Natalie Koch, "Greening oil money: The geopolitics of energy finance going green," *Energy Research & Social Science* 93, 102833 (November 2022): 7, https://doi.org/10.1016/j.erss.2022.102833.
[162] Aminjonov, "Policy Innovations," 2400.
[163] Young, *Energy, Finance and Security*, 95.
[164] I-Tsung Tsai, "Political Economy of Energy Policy Reforms in the Gulf Cooperation Council: Implications of Paradigm Change in the Rentier Social Contract," *Energy Research & Social Science* 41, (July 2018): 92, https://doi.org/10.1016/j.erss.2018.04.028.
[165] Koch, "Greening," 1–2.
[166] Ibid., 87–88.
[167] Luomi, "International Relations," 15.

to solar energy production and the central involvement in the governance thereof signal an increase in state capacity, strengthening legitimacy and recognition internationally. Domestically, the sustainable energy sector and its revenues permit the continuation of clientelist relationships, preserving state power.[168] These processes clearly illustrate the mutual exchanges between society and nature.

The metabolism of solar energy production also signals interconnectedness with the water and food challenges. For instance, a considerable amount of the UAE's energy consumption stems from energy-intensive desalination technologies, raising energy demand and the necessity of finding alternative energy production methods.[169] As will be shown in the next chapter, large domestic agricultural projects during the first three decades after the establishment of the federation also drew large amounts of energy. Furthermore, the specific application of solar energy technologies indicates linkages to other environmental challenges. For instance, the powering of desalination plants through CSP technology is being explored by the UAE, capitalizing on the potential of co-generating water and electricity.[170] Additionally, as noted, water scarcity and land abundance in the UAE – both connected to the water and food challenges – have caused the mixed use of PV and CSP technology, as both have their own weaknesses and strengths in relation to these environmental characteristics. These observations stress the interconnectedness of the environmental challenges explored in this research, in line with my fourth hypothesis.

As in Chapter 3, I also find a more ambiguous role for natural resources through its contribution to high energy demand and the related excessive extraction. While higher demand, on the one hand, heightens the necessity of the energy transition, on the other hand, it complicates the energy challenge by adding to the effects of fossil fuel extraction in terms of climate change and decreasing existing supply.[171] This demonstrates that natural resources, paradoxically, have not only facilitated the energy transition but also complicated the energy challenge.

4.5. Conclusion

Air pollution, climate change, and the ever-approaching depletion of fossil fuels have presented the UAE with an energy challenge. As a result, the state needed to diversify its energy mix with low-carbon energy sources. The UAE is in the midst of this transition, aiming to rapidly increase the share of low-carbon energy in its domestic energy mix. Solar energy

[168] Aminjonov, "Policy Innovations," 2402–2403; Young, *Energy, Finance and Security*, 95.
[169] Kazim, "Energy consumption," 431–434.
[170] Jay Hilotin, "Solar-powered desalination: what you need to know," *GulfNews*, March 22, 2023, https://gulfnews.com/special-reports/solar-powered-desalination-what-you-need-to-know-1.1679487975835.
[171] Al-Mamaary, Kazem, and Chaichan, "Climate change," 557.

production has come forward as an essential component of the Emirati future energy strategy. However, it presently still accounts for a mere 1.1% of domestic energy consumption.

The role of natural resources in the metabolism of solar energy highlights the interconnectedness of humans and nature in the management of environmental challenges, supporting my argument. Natural resources are found to have influenced evolving, complex social, political, economic, and environmental processes that have enabled and motivated the transition toward solar energy. An increasing energy demand and decreasing supply, driven by natural resources, coupled with international political and economic factors revolving around oil, have incentivized the shift towards unconventional energy production. Meanwhile, high regional solar rates have promoted the application of solar energy in the UAE. Furthermore, this chapter has demonstrated the enabling role of natural fossil fuel reserves in the metabolism of solar energy by enriching and empowering the state, in line with my second hypothesis. The successes in solar energy management have, in turn, also heightened domestic and international legitimacy, highlighting the mutual exchanges between humans and nature. Moreover, the solar energy metabolism and its defining mechanisms are shown to be intertwined with water and food challenges. Challenging my assumptions, natural resources can also be argued to have complicated the energy challenge. As previously noted, however, this interpretation also stresses the interconnectedness between and within societal and natural ecosystems and their transformation over time. In sum, this chapter's findings largely underline this thesis' argument and support my four hypotheses.

Chapter 5. Food in the UAE: Land Grabs

5.1. Introduction

This chapter analyzes the political-ecological metabolism of land grabs, untangling the various, complex linkages between this food security strategy and natural resources. With little arable land and natural fresh water, achieving food security has been a challenging issue for the Emirati rulers. In the wake of the food price spike of 2007-2008, the UAE started to shift towards a new food strategy: the large-scale acquisition of foreign land.[172] This chapter, first, contextualizes the strategy of land grabs by delineating the food challenge and the history of the state's dealing with food security. Second, the process of foreign land acquisitions by the UAE is assessed. The third section examines the role of natural resources in shaping these land grabs. In doing so, this chapter argues that the UAE's food security strategies are deeply linked to social, economic, political, and environmental processes intertwined with natural resources, again demonstrating the interlacement of society and nature.

5.2. The food challenge and the development of food security strategies

The UAE has encountered several challenges in its effort to ensure food provision to its citizens. The regional lack of arable land has made conventional methods of achieving food security through domestic agriculture complicated. A related hot arid climate and natural freshwater scarcity have caused agriculture to be a complex endeavor.[173] Meanwhile, climate change has exacerbated the UAE's harsh environment by causing higher temperatures and lower levels of precipitation.[174] Furthermore, after the oil boom, rapid population growth, large amounts of expatriate workers, and growing tourist numbers have drastically increased food consumption, further inflaming this food challenge.[175] Moreover, the UAE has aimed to prevent an overreliance on food imports, in line with broader diversification and socioeconomic development efforts.[176] In light of these developments, the state was presented a significant challenge.

As a result, the UAE's food security strategy has undergone a drastic, state-led transformation in the first decades after the establishment of the federation. Before 1971, the food sector in the individual emirates was still largely self-sustaining and focused on smallholder agriculture. Meanwhile, food deficits were filled by regional and international trade.

---

[172] Adam Hanieh, *Money, Markets, and Monarchies: The Gulf Cooperation Council and the Political Economy of the Contemporary Middle East* (Cambridge: Cambridge University Press, 2018), chap. 4, introduction.
[173] Henderson, "Land grabs," 262; Khalil Ammar et al., "Developing an analytical framework for estimating food security indicators in the United Arab Emirates: A review," *Environment, Development and Sustainability* (2023): introduction, https://doi.org/10.1007/s10668-023-03032-3.
[174] Szabo, "The Water Challenge," 3; Zubari, "Water Security," 93.
[175] Hanieh, *Money*, chap. 4.1.
[176] Davidson, *The United Arab Emirates*, 130; Henderson, "Land Grabs," 266.

In the 1970s, however, concomitant with the state's socioeconomic development engendered by oil wealth, the UAE saw a rise in food demand due to several related factors, including population growth, urbanization, rising living standards, and declining smallholder agricultural production. Facilitated by its increasing economic and political power, the federation sought to counter an ever-growing dependency on food imports. As such, a policy of large-scale domestic production was pursued, promoted by the allocation of land and subsidies.[177]

This strategy proved relatively fruitful but also affected the political-ecological metabolism. While the 1990s saw massive gains in the expansion of cultivated lands and agricultural output, successfully reducing the UAE's dependence on food imports, these projects relied on pumping groundwater from deep aquifers – a costly and energy-intensive process. The practice also contributed to the further depletion of the UAE's increasingly scarce natural freshwater resources.[178]

In response to these factors, from the 2000s onwards, the UAE's food security strategy shifted away from domestic production and towards offshore projects. By acquiring farmland overseas, the UAE intended to overcome these adverse metabolic effects while ensuring a degree of self-sufficiency. The idea was that these land grabs would safeguard against market volatility by adopting a hedging strategy and allow for greater control over the food chain through vertical integration.[179] The rise of global food prices since 2004 and the 2007-2008 price spike illuminated the risks of food import reliance, accelerating the development of this unconventional food security strategy.[180]

The acquisition of foreign farmlands has effectively ensured a secure food supply, despite the complications of early projects. Initial investments in the post-2008 period predominantly focused on countries across Africa and Asia but often failed to materialize, partly due to local resistance and political backlash in target countries. Therefore, the UAE has since turned to countries that are considered more open to foreign investments. In this light, foreign land acquisitions were made in the Middle East and, more significantly, in wealthier states with ample farming land and stronger property rights protection.[181] While these offshore agricultural projects were indeed more ambitious than their eventual reality, it has

[177] Henderson, "Land grabs," 266; Henderson and Ziadah, "Food regime," 5.
[178] Davidson, *The United Arab Emirates*, 129–130; Henderson and Ziadah, "Food regime," 5; Henderson, "Land grabs," 267.
[179] Henderson and Ziadah, "Food regime," 5–6.
[180] Hanieh, *Money*, chap. 4.1.
[181] Ernest Nkansah-Dwamena and Hyunsoo Yoon, "Why is sub-Saharan Africa an attractive destination to foreign land grabbers? Evidence from country characteristics," *African Development Review* 32, no. 2 (June 2022): 287–288, https://doi.org/10.1111/1467-8268.12632; Eckart Woertz, "The Governance of Gulf Agro-Investments," *Globalizations* 10, no. 1 (2013): 92, http://dx.doi.org/10.1080/14747731.2013.760932; Hanieh, *Money*, chap. 4.1.

been demonstrated that they still produce comestibles on a large scale.[182] This has allowed for a self-sufficient supply of agricultural commodities with less significant domestic environmental impact. However, due to the absence of data, the share of these projects in domestic food consumption is difficult to quantify.

However, other strategies to address the food challenge continue to be explored. Concomitant with its land grabs policy, the UAE has altered its policy towards food imports. While land grabs have been instrumental in enhancing food security, the state has remained predominantly reliant on imported commodities. Between 80% and 90% of the country's food consumption is still met by food imports.[183] Starting in the 2000s, the UAE has attempted to diversify its food supply as the country began purchasing food from a variety of suppliers on the global market. This effort further advanced the state's strategy to reduce its vulnerability to supply chain disruptions and price fluctuations.[184] Furthermore, in recent years, the UAE has signaled a renewed commitment to developing the agricultural sector.[185] These ambitions rely on local farming and primarily focus on technological innovation and sustainability.[186] The effects of such policies, however, are yet to materialize, and given the negligible contribution of domestic food production to national consumption and the challenges that face local agriculture, these aspirations still seem far away.[187]

The UAE has made significant progress in addressing its food challenge by implementing a comprehensive food security strategy, with the practice of foreign land grabs as a significant component.[188] As a result, the country has achieved a certain degree of self-sufficiency and made substantial strides in overcoming food security issues. However, the UAE's food strategy is still vulnerable, as the state remains principally reliant on the import of agricultural commodities. At the same time, the country continues to be confronted with increasing demand, given its rising population levels and living standards. Moreover, foreign

[182] Berhanu Degefa, "Food Security in the UAE," in *Facets of Security in the United Arab Emirates*, eds. William Gueraiche, Kristian Alexander (Abingdon: Routledge, 2022), "Strategies to overcome food insecurity," https://doi.org/10.4324/9781003025566-12; Henderson, "Land grabs," 269–271.
[183] Tara Fischbach, "Advancing food security in the UAE," *Mohammed Bin Rashid School of Government* (January 2018): 9, https://mbrsgcdn.azureedge.net/cmsstorage/mbrsg/files/85/859ddec7-f5ed-48dd-99dd-4e1b8f326112.pdf
[184] Henderson and Ziadah, "Food regime," 5–6.
[185] Degefa, "Food Security," "Strategies to overcome food insecurity"; "National Food Security Strategy 2051," U.AE, accessed May 6, 2023, https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/national-food-security-strategy-2051.
[186] Nick Webster, "UAE outlines plan to increase domestic food production and consumption," *The National News*, March 22, 2023, https://www.thenationalnews.com/uae/2023/03/22/uae-outlines-plan-to-increase-domestic-food-production-and-consumption/.
[187] Azzeddine Azzam and Belaid Rettab, "A welfare measure of consumer vulnerability to rising prices of food imports in the UAE," *Food Policy* 37, no. 5 (October 2012): 554–555, https://doi.org/10.1016/j.foodpol.2012.05.003; Shahin and Salem, "Water Scarcity," 3–4.
[188] Henderson, "Land grabs," 269–271.

land acquisitions are also argued to be limited in terms of self-sustenance since target countries could impose export restrictions in times of worldwide crises.[189]

5.3. The practice of land grabs

Emirati offshore agricultural projects are mainly located in the Middle East and in wealthy investor-friendly states with abundant farmland and adequate natural water resources.[190] The most extensive programs are operative in the US, Serbia, Italy, Spain, Egypt, Sudan, South Africa, and Vietnam, with a sum of 365,000 acres of land purchased or leased. Egypt has been the principal target country, with at least 170,000 acres of its land serving the UAE's food commodities chain.[191]

These projects represent de facto Emirati enclaves in host countries, where agricultural commodities are produced in relative isolation and, afterward, transported to the UAE. Farmland is acquired or leased from host countries, either as part of larger agricultural projects or as a standalone initiative. In most cases, subsequently, vacant land is developed into agrarian spaces, applying fertilizers to transform the soil adequately. Automatic processes coordinate soil amendment and irrigation of land. GPS-driven machinery disperses fertilizers, while water is spread using automated booms. As a result, little labor is required to manage these sites. Post-harvesting, the crops are processed and transported to the shipping location. From this place, the commodities are sorted and delivered to the UAE through air or sea freight, where the food is distributed on the local market. This process is marked by marginal outside involvement, while, in contrast, these projects adversely impact foreign environments.[192]

Indeed, although the shift from domestic to foreign agricultural projects reduces domestic ecological costs, offshore cultivation remains a process marked with natural resource involvement. The large-scale irrigation systems employed in these extensive projects require substantial amounts of water, which are commonly extracted from a local water source. As such, these agro-projects are often positioned near natural freshwater sources.[193] Furthermore, offshore projects rely on energy-intensive methods, such as the delivery of water to these spaces, the distribution of water on the farms, and the powering of irrigation channels.[194] Therefore, in some instances, solar plants have been installed on-site to mitigate

[189] Fischbach, "Food Security," 33.
[190] Hanieh, *Money*, chap. 4.1.
[191] Ibid., chap. 4.1, chap. 4.2.; Henderson, "Land grabs," 271.
[192] Henderson, "Land grabs," 272; Henderson and Ziadah, "Food regime," 7–8.
[193] Henderson, "Land grabs," 271–272.
[194] Nada Arafat and Saker El Nour, "How Egypt's water feeds the Gulf," *Mada Masr*, May 15, 2019, https://www.madamasr.com/en/2019/05/15/feature/politics/how-egypts-water-feeds-the-gulf/.

high energy demand.[195] This clearly demonstrate the interconnectedness between natural resources and environmental management, as well as the linkages between different metabolisms, albeit in a foreign space.

The acquisition and management of foreign farmlands are primarily carried out by Emirati firms, although their role is intertwined with that of the state. Most notably, Al Dahra and Jenaan have undertaken land grab practices. The former owns 200,000 acres of foreign land, while the latter has bought or leased a minimum of 165,000 acres. However, their involvement in UAE food provision exceeds merely operating these offshore spaces, as these firms have engaged in vertical integration within the food supply chain. In this context, Emirati companies have expanded their operations to the transportation sector or invested in logistics firms. As a result, such firms have come to coordinate virtually every stage of the agricultural commodities supply chain. Nevertheless, the role of the state within these processes is significant. The UAE government actively encouraged foreign agro-investments, offering financial support such as subsidies to firms that sought to acquire offshore land. Furthermore, the UAE employed political and diplomatic channels to promote land deals. At times the state even acted as a broker, offering various benefits to investor companies and target countries alike. Consequently, investing firms often enjoy close connections to the state.[196]

5.4. Natural resources and shaping land grabs

Natural resources have facilitated the practice of foreign land grabs through a spectrum of complex social, economic, political, and environmental processes, in line with my first hypothesis. Most directly, as stated, the sheer absence of arable land and related freshwater resources has largely motivated the UAE to initiate the transition from domestic to foreign large-scale agro-projects.[197] Additionally, the selection of target states for these agrarian spaces has been based on the availability of farmland and fresh water, besides economic and political factors.[198] Within these host countries, moreover, the extraction of water has determined the locations of farmlands. Although the availability of land and water resources, thus, shaped the eventual logistics of land grabs in foreign spaces, this is of limited relevance to this study, which is primarily concerned with the Emirati environment and its natural resources.

Natural resources have also incentivized foreign land acquisitions by affecting domestic food demand and supply, mirroring observations in the previous chapters. The

[195] Henderson, “Land grabs,” 272.
[196] Hanieh, *Money*, chap 4.1; Henderson, “Land grabs,” 269–271; Woertz, *Oil for Food*, 213–217.
[197] Henderson, “Land grabs,” 267–268.
[198] Nkansah-Dwamena and Yoon, “Foreign land grabbers,” 87–88; Woertz, *Oil for Food*, 148.

socioeconomic development – engendered by the UAE's hydrocarbon exports – has increased food demand and, as argued in Chapter 3, contributed to the depletion of natural freshwater resources necessary for land cultivation. Oil wealth fueled processes of population growth, urbanization, rising living standards, declining smallholder agriculture, industrialization, and the influx of expatriate workers, which all increased the demand for food and the reliance on food imports. In response, the UAE rapidly expanded domestic agricultural projects, relying heavily on domestic groundwater aquifers. In the process of their inevitable depletion, these projects began to lose their profitability. This, finally, incentivized the acquisition of land grabs, revealing the implicit incentivizing role of hydrocarbon resources in foreign agro-projects.[199]

Fossil fuel resources have also enabled land-grabbing practices by providing the UAE state with economic and political power. The financial resources obtained through oil extraction have made co-financing large-scale offshore agricultural sites possible. Also, they have allowed for significant investments in the logistical sector that served the vertical integration of firms that came to control the Emirati food supply chain.[200] In addition, in its efforts to broker deals between Emirati firms and target states, the UAE has leveraged its economic and political power, which it derived from its oil and gas wealth.[201] This central role of oil and power in the management of the food challenge offers support for my second hypothesis.

Furthermore, as I hypothesized, while oil has presented the UAE with power needed to engage in offshore agro-projects, the successful management of these projects, in turn, has also reinforced its power. By ensuring the provision of food to its population, agricultural development prior to the shift toward foreign land acquisitions had already strengthened the state's power.[202] In this context, land grabs represent a continuation and solidification of this process by enhancing domestic food security and control over agricultural production and distribution.[203] Moreover, the generous financial aid distributed to Emirati agricultural firms partaking in foreign land acquisitions ensured the accruement of rent by the domestic elite.[204] This transformation of rentier structures, thus, partly served the endurance of state power. On an international scale, the state has also extended its power through land-grabbing practices. As noted, the vertical integration of Emirati state-affiliated firms ensured their involvement in

[199] Ibid., 266–268.
[200] Henderson and Ziadah, "Food regime," 5.
[201] Woertz, *Oil for Food*, 216–217.
[202] Sabrina Joseph, "Farming the desert: agriculture in the oil frontier, the case of the United Arab Emirates, 1940s to 1990s," *British Journal of Middle Eastern Studies* 45, no. 8 (2018): 678–694, https://doi.org/10.1080/13530194.2017.1320977.
[203] Hanieh, *Money*, chap 4.1.
[204] Henderson, "Land grabs," 269; Ibid.

each stage of the food metabolism. This affected not only the state's domestic power through its dominance in food production and distribution but also its power in the international agricultural supply chain. The internationalization of the UAE's food security strategy, therefore, represents rather a logistical security strategy aimed at securing trade routes and asserting influence in the supply chain.[205] These mechanisms demonstrate the reciprocal relationship between state power and environmental management.

The metabolism of land grabs shows strong ties with other environmental challenges, with a particularly notable connection to the water challenge. This is unsurprising, as food production relies heavily on the local availability of fresh water. The exhaustion of natural groundwater that motivated the transition away from domestic production also stimulated the large-scale application of desalination technology to provide fresh water. Domestic agriculture was primarily responsible for the exhaustion, at its peak consuming 90% of natural water supplies in the UAE. Further down the metabolism, the application of desalination also has affected energy consumption, as shown in Chapter 3 and 4.[206] However, in terms of offshore agro-projects, while land grabs are infamous for their excessive water demand in host countries, their impact on the national water challenge has been relatively limited.[207]

Natural resources have not only enabled but also complicated the management of the food challenge, a finding that is consistent across the various metabolisms of environmental challenges. As previously mentioned, the hydrocarbon-led socioeconomic development in the UAE has increased food and water demand. Besides incentivizing the initiation of land grabs, this heightened the UAE's reliance on food imports, further complicating the food challenge. Moreover, sharing similarities with the metabolism desalination, the rising water and food demand, as well as fossil fuel-induced climate change, have contributed to the depletion of natural freshwater resources and the subsequent demise of domestic agriculture. These findings can be interpreted to challenge my first hypotheses.

5.5. Conclusion

In response to the food challenge, the UAE has engaged in foreign land acquisitions. The lack of arable land and natural water in the country has caused self-sufficiency in the provision of food to be a long-standing issue. Since the 1970s, food provision has been further endangered by an ever-growing demand and the depletion of natural water reserves necessary for domestic agricultural initiatives. The salience of this food challenge peaked with the food price spike of 2007-2008, accelerating efforts to achieve food self-sufficiency. The practice of land

[205] Hanieh, *Money*, chap 4.1; Henderson and Ziadah, "Food regime," 7–9.
[206] Henderson, "Land grabs," 268.
[207] Arafat and El Nour, "Egypt's water."

grabs has functioned to deal with these issues, as it secured direct supplies from offshore agrarian spaces to the domestic market, effectively mitigating the food challenge.

This chapter offers strong support for my argument and hypotheses. Natural resources are entrenched in the metabolism of land grabs, underlining the interconnectedness of humans and nature in the context of environmental challenges. Through various social, economic, political, and environmental processes, natural resources – predominantly oil and water – have impelled the UAE to abandon domestic agriculture and engage in large-scale offshore agro-projects. Oil has granted the UAE the political and economic power necessary to coordinate and realize foreign land acquisitions by fostering power consolidation and accruing wealth. At the same time, by engaging in land grabbing, the UAE has also been shown to reinforce its power, continuing rentier structures and dominating increasingly large parts of the agricultural supply chain. Furthermore, the metabolism of these projects shows connections to the water and energy challenges, most strongly in relation to the former, as water is essential in food production. However, in line with the previous chapters, this chapter has also shown that the extraction of hydrocarbons has implicitly complicated the food challenge. At the same time, this ambiguous relationship between natural resources and environmental management stresses the interconnectedness of humans and nature. In general, these findings indicate support for my hypotheses.

Conclusion

In this thesis, I have analyzed the political-ecological metabolisms of strategies to deal with environmental challenges in the UAE in relation to water, energy, and food. The first chapter has contextualized this research, outlining the theoretical framework on which this research builds and evaluating the literature on human-environment relations in the Middle East. In the second chapter, an overview has been provided of the relationship between oil and development in the history of the UAE. These insights have laid the foundation for understanding the role of oil in environmental management strategies. The three chapters that followed have examined the metabolisms of desalination, solar energy, and land grabs. Applying the theoretical framework, these chapters paid specific attention to the role of natural resources and power relations in social, political, economic, and environmental factors that transform over time and have shaped environmental management in the UAE.

In doing so, this study has revealed that humans and nature are intertwined. I have found support for all four hypotheses. With respect to the first hypothesis, a wide array of metabolic exchanges between environmental management and natural resources have been identified. These exchanges have often occurred through complex social, economic, political, and environmental processes and have facilitated environmental management strategies. These processes, as well as their context, have evolved over time, affecting the working of the political-ecological metabolism. In line with my second hypothesis, oil has been pivotal in this regard by providing the state with the power and financial resources necessary to engage in the management of environmental challenges. Highlighting the interdependence of humans and nature through mutual metabolic exchanges, successful environmental management has, in turn, also forged the power and legitimacy of the state, as per my third hypothesis. This also demonstrates the cyclic and transformative nature of the political-ecological metabolism. The fourth hypothesis is also confirmed, as vivid interactions were identified between the various metabolisms of interest. Complementing these findings, I also found that natural resources have not only enabled but also impeded effective dealing with environmental challenges. This ambiguous relationship is explained by the interpretation of rising environmental demand and diminishing supply as both an impetus for the shift toward a particular environmental strategy and a detriment to the related environmental challenge. Nevertheless, this polysemy underscores the close interdependent relations between society and nature.

These findings have implications in the academic literature and beyond. They suggest that the focus on environmental factors in explaining adverse social, economic, and political outcomes in the literature on human-environment relations the Middle East is unfounded. Whereas conditions of scarcity and abundance in conventional academic wisdom are often

thought to lead to crises and hardship, this study has shown that natural resources have been intertwined in processes that have enabled the inhabitants of the Middle East to overcome environmental challenges. As such, instead of a complete absence of human agency, I argue that society and nature demonstrate a shared agency in the context of the Middle East. The findings of this thesis are also relevant for political and social actors, as they underscore the need to consider environmental, social, and economic policy not only in relation to one another but also in conjunction with politics. This insight should be taken into account when formulating and evaluating policy.

Yet, this study is not without its limitations. First, the emphasis on natural resources has caused an incomprehensive image of the entirety of shaping forces in environmental management in the UAE. This has led to the exclusion of some variables in this study that have also been key in shaping strategies to that address environmental challenges. Second, relatedly, this thesis has dealt only to a limited extent with the differences in environmental and resource management between the various emirates. However, these considerations were beyond the scope of this research.

Therefore, future political ecology research should focus on establishing a comprehensive study of environmental management in the UAE, widening the scope beyond the role of natural resources. Such studies should also take into account the diverse nature of environmental management in the various emirates. Furthermore, future scholarship should test the findings of this thesis in other contexts within the Middle East; on a regional, national, or subnational scale.

Bibliography

Abed, Ibrahim, and Peter Hellyer. *United Arab Emirates A New Perspective*. London: Trident Press, 2001.

Abdulrahman Alsharhan and Zeinelabidin Rizk. *Water Resources and Integrated Management of the United Arab Emirates*. Springer: Berlin, 2020.

Abu Dhabi Distribution Company. "Our company." Accessed April 13, 2023. https://www.addc.ae/en-US/home/Pages/AboutUs.aspx.

Abulof, Uriel. "'Can't buy me legitimacy': the elusive stability of Mideast rentier regimes." *Journal of International Relations and Development* 20 (2017): 55–79. https://doi.org/10.1057/jird.2014.32.

AgruAmerica. "How to Create a Desalination Pipeline System." Accessed April 12, 2023. https://agruamerica.com/desalination-pipeline-system/

Ahmar, Abir. "Parched UAE turns to science to squeeze more rainfall from clouds." *Reuters*, August 30, 2022. https://www.reuters.com/world/middle-east/parched-uae-turns-science-squeeze-more-rainfall-clouds-2022-08-30/.

Al-Maamary, Hilal, Hussein A. Kazem, and Miqdam T. Chaichan. "Climate Change: The Game Changer in the Gulf Cooperation Council Region." *Renewable and Sustainable Energy Reviews* 76, (September 2017): 555–576. https://doi.org/10.1016/j.rser.2017.03.048.

Al-Sarihi, Aisha, Michael Mason. "Challenges and opportunities for climate policy integration in oil-producing countries: the case of the UAE and Oman." *Climate Policy* 20, no. 10 (2020): 1226–1241. https://doi.org/10.1080/14693062.2020.1781036.

Aminjonov, Farkhod. "Policy Innovations and Rationale for Sustainable Energy Transition in the UAE." *Social Science Quarterly* 101, no. 7 (December 2020): 2398–2412. https://doi.org/10.1111/ssqu.12909.

Ammar, Khalil, Ahmed Kheir, Beshir Ali, Balan Sundarakani, and Ioannis Manikas. "Developing an analytical framework for estimating food security indicators in the United Arab Emirates: A review." *Environment, Development and Sustainability* (2023). https://doi.org/10.1007/s10668-023-03032-3.

Arabian Business. **"**Al Maktoum Solar Park adds another 300MW to Dubai's clean energy production." November 1, 2022. https://www.arabianbusiness.com/industries/energy/al-maktoum-solar-park-adds-another-300mw-to-dubais-clean-energy-production

Arabian Business. "Maktoum Solar Park's fourth and fifth phases all set to meet 2023 deadline." August 23, 2022.

https://www.arabianbusiness.com/industries/energy/maktoum-solar-parks-fourth-and-fifth-phases-all-set-to-meet-2023-deadline.

Arafat, Nada, and Saker El Nour. “How Egypt’s water feeds the Gulf.” *Mada Masr*. May 15, 2019. https://www.madamasr.com/en/2019/05/15/feature/politics/how-egypts-water-feeds-the-gulf/.

Azzam, Azzeddine, and Belaid Rettab. “A welfare measure of consumer vulnerability to rising prices of food imports in the UAE.” *Food Policy* 37, no. 5 (October 2012): 554–555. https://doi.org/10.1016/j.foodpol.2012.05.003

Barnett, Jon, and W. Neil Adger. “Climate Change, Human Security and Violent Conflict.” *Political Geography* 26, no. 6 (August 2007): 639–55. https://doi.org/10.1016/j.polgeo.2007.03.003.

Benli Altunişik, Meliha. “Rentier State Theory and the Arab Uprisings: An Appraisal.” *The Middle East Journal* 63, no. 3 (Summer 2010): 75–91. https://www.jstor.org/stable/43925852.

Berdikeeva, Saltanat. “Water-Scarce UAE Bets on Solar-Powered Water Desalination.” *Inside Arabia*, July 20, 2019. https://insidearabia.com/water-scarce-uae-bets-on-solar-powered-water-desalination/.

Cavalcanti, Tiago de, Kamiar Mohaddes, and Mehdi Raissi. “Does Oil Abundance Harm Growth?” *Applied Economics Letters* 18, no. 12 (2011): 1181–1184. https://doi.org/10.1080/13504851.2010.528356.

Carey II, Peter, Curtis Bell, Emily Hencken Ritter, and Scott Wolford. “Oil Discoveries, Civil War, and Preventive State Repression.” *Journal of Peace Research* 59, no. 5 (September 2022): 648–662. https://doi.org/10.1177/00223433211047365.

Choucri, Nazli, Daniel Goldsmith, and Touzic Mezher, “Renewable Energy Policy in an Oil-Export Country: The Case of the United Arab Emirates.” *Renewable Energy Law and Policy Review* 1, no. 1 (2010): 77–86. https://www.jstor.org/stable/24324589.

Davidson, Christopher M. *The United Arab Emirates: A Study in Survival*. Boulder, Colorado: Lynne Rienner Publishers, 2005.

Davis, Dianna. “Imperialism, Orientalism, and the Environment in the Middle East.” in *Environmental Imaginaries of the Middle East*, edited by Diana Davis and Edmund Burke III (Athens, Ohio: Ohio University Press, 2011): 1–16.

Davis, Dianna. “Historical Approaches to Political Ecology.” In *The Routledge Handbook of Political Ecology*, edited by Tommy Perreault, Gavin Bridge, and James McCarthy (London: Routledge, 2015): 263–276.

Dawoud, Mohamed, Osama Sallam, and Mahmoud Abdelfattah, “Treated wastewater management and reuse in arid regions: Abu Dhabi case study,” *The 10th Gulf water*

conference, Doha, Qatar (2012): 732–752. https://www.researchgate.net/publication/259182543_Treated_Wastewater_Management_and_Reuse_in_Arid_Regions_Abu_Dhabi_Case_Study.

Degefa, Berhanu. “Food Security in the UAE.” In *Facets of Security in the United Arab Emirates*, eds. William Gueraiche, Kristian Alexander (Abingdon: Routledge, 2022). https://doi.org/10.4324/9781003025566-12.

Dolatyar, Mostafa, and Tim Gray. “The Politics of Water Scarcity in the Middle East.” *Environmental Politics* 9, no. 3 (2000): 65–88. https://doi.org/10.1080/09644010008414538.

Dreher, Axel, and Merle Kreibaum. “Weapons of Choice: The Effect of Natural Resources on Terror and Insurgencies.” *Journal of Peace Research* 53, no. 4 (July 2016): 539–53. https://doi.org/10.1177/0022343316634418.

Dunning, Thad. *Crude Democracy: Natural Resource Wealth and Political Regimes*. Cambridge, England: Cambridge University Press, 2009. https://doi.org/10.1017/cbo9780511510052.

Embassy of the United Arab Emirates, Washington DC. “Energy Diversification.” Accessed April 21, 2023. https://www.uae-embassy.org/discover-uae/climate-and-energy/uae-energy-diversification.

Embassy of the United Arab Emirates, Washington DC. “History.” Accessed April 1, 2023. https://www.uae-embassy.org/discover-uae/history#:~:text=An%20agreement%20was%20reached%20between,established%20on%20December%202%2C%201971.

Erb, Karl-Heinz, et al. “Beyond Inputs and Outputs: Opening the Black-Box of Land-Use Intensity.” In *Social Ecology*, edited by Helmut Haberl, Marina Fischer-Kowalski, Fridolin Krausmann, and Verena Winiwarter (Berlin: Springer, 2016): 93–124.

EWEC. “Noor Abu Dhabi.” EWEC. Accessed April 25, 2023. https://www.ewec.ae/en/power-plants/noor-abu-dhabi.

Fischbach, Tara. “Advancing food security in the UAE.” *Mohammed Bin Rashid School of Government* (January 2018). https://mbrsgcdn.azureedge.net/cmsstorage/mbrsg/files/85/859ddec7-f5ed-48dd-99dd-4e1b8f326112.pdf.

Foster, John Bellamy. “Marx's Theory of Metabolic Rift: Classical Foundations for Environmental Sociology.” *American Journal of Sociology* 105, no. 2 (September 1999): 366–405. https://doi.org/10.1086/210315.

Fountain, Henry. “The World Can Make More Water From the Sea, but at What Cost?” *New York Times,* October 25, 2019. https://www.nytimes.com/2019/10/22/climate/desalination-water-climate-change.html.

Gambrell, Jon. “IMF says Gulf Arab states may deplete oil savings in 15 years.” *PBS*, February 6, 2020. https://www.pbs.org/newshour/economy/imf-says-gulf-arab-states-may-deplete-oil-savings-in-15-years.

Ghirard, Elisa, Giovanni Brumana, Giuseppe Franchini, Antonio Perdichizzi. “The optimal share of PV and CSP for highly renewable power systems in the GCC region.” *Renewable Energy* 179 (December 2021): 1990–2003. https://doi.org/10.1016/j.renene.2021.08.005.

Gleick, Peter. “Water as a Weapon and Casualty of Armed Conflict: A Review of Recent Water-related Violence in Iraq, Syria, and Yemen.” *WIREs Water* 6, no. 4 (July/August 2019): 1–15. https://doi.org/10.1002/wat2.1351.

Gleick, Peter. “Reducing the Risks of Conflict over Fresh Water Resources in the Middle East.” *Studies in Environmental Science* 58 (1994): 41–54. https://doi.org/10.1016/s0166-1116(08)71399-2.

Global Media Insight. “Dubai Tourism Statistics 2023.” March 13, 2023. https://www.globalmediainsight.com/blog/dubai-tourism-statistics/.

Grey, Matthew. “A Theory of “Late Rentierism” in the Arab States of the Gulf.” *CIRS Occasional Paper* 7 (2011). http://dx.doi.org/10.2139/ssrn.2825905.

Günel, Gökçe. “The Infinity of Water: Climate Change Adaptation in the Arabian Peninsula.” *Public Culture* 28, no. 2(79) (May 2016): 295–315. https://doi.org/10.1215/08992363-3427463.

Hachicha, Ahmed, Israa Al-Sawafta, Dhouha Ben Hamadou. “Numerical and experimental investigations of dust effect on CSP performance under United Arab Emirates weather conditions.” *Renewable Energy* 143 (December 2019): 263–276. https://doi.org/10.1016/j.renene.2019.04.144.

Hanieh, Adam. Money, Markets, and Monarchies: The Gulf Cooperation Council and the Political Economy of the Contemporary Middle East. Cambridge: Cambridge UP, 2018.

Henderson, Christian. “Land Grabs Reexamined: Gulf Arab Agro-Commodity Chains and Spaces of Extraction.” *Environment & Planning* 53, no. 2 (March 2021): 261–279. https://doi.org/10.1177/0308518x20956657.

Henderson, Christian, and Rafeef Ziadah. “Logistics of the Neoliberal Food Regime: Circulation, Corporate Food Security and the United Arab Emirates.” *New Political Economy* (December 2022): 1–16. https://doi.org/10.1080/13563467.2022.2149721.

Herb, Michael. *The Wages of Oil*. New York: Cornell University Press, 2015.

Hilotin, Jay. “Solar-powered desalination: what you need to know.” *GulfNews*. March 22, 2023. https://gulfnews.com/special-reports/solar-powered-desalination-what-you-need-to-know-1.1679487975835.

Hoffmann, Clemens. “Beyond the resource curse and pipeline conspiracies: Energy as a social relation in the Middle East,” *Energy Research & Social Science* 41, (July 2018): 39–47. https://doi.org/10.1016/j.erss.2018.04.025.

Hoffman, Clemens. “Environmental determinism as Orientalism: The geo-political ecology of crisis in the Middle East.” *Journal of Historical Sociology* 31, no. 1 (March 2018): 94–104. https://doi.org/10.1111/johs.12194.

Homer-Dixon, Thomas F. *Environment, Scarcity, and Violence*. New Jersey: Princeton University Press, 1999.

Ide, Tobias. “Climate War in the Middle East? Drought, the Syrian Civil War and the State of Climate-Conflict Research.” *Current Climate Change Reports* 4, no. 4 (December 2018): 347–354. https://doi.org/10.1007/s40641-018-0115-0.

Jamil, Farzana Ahmad, and Y. Jeon. “Renewable Energy Technologies Adopted by the UAE: Prospects and Challenges – A Comprehensive Overview.” *Renewable and Sustainable Energy Reviews* 55, (March 2016): 1181–94. https://doi.org/10.1016/j.rser.2015.05.087.

John, Issac. “UAE's economy growth momentum set to pick up.” *Khaleej Times,* December 27, 2013. https://bit.ly/3CeXCOn.

Jones, Toby C. *Desert Kingdom: How Oil and Water Forged Modern Saudi Arabia*. Cambridge, Mass.: Harvard University Press, 2010.

Joseph, Sabrina. “Farming the desert: agriculture in the oil frontier, the case of the United Arab Emirates, 1940s to 1990s.” *British Journal of Middle Eastern Studies* 45, no. 8 (2018): 678–694. https://doi.org/10.1080/13530194.2017.1320977.

Kazim, Ayoub. “Assessments of primary energy consumption and its environmental consequences in the United Arab Emirates,” in *Renewable and Sustainable Energy Reviews* 11, no. 3: 426–446. https://doi.org/10.1016/j.rser.2005.01.008.

Kazim, Ayoub, T. Veziroglu. “Utilization of solar–hydrogen energy in the UAE to maintain its share in the world energy market for the 21st century,” *Renewable Energy* 24, no. 2 (October 2001): 259–274. https://doi.org/10.1016/S0960-1481(00)00199-3.

Koch, Natalie. “Sustainability Spectacle and ‘Post-Oil’ Greening Initiatives.” *Environmental Politics* (September 2022): 1–24. https://doi.org/10.1080/09644016.2022.2127481.

Koubi, Vally. “Climate Change and Conflict.” *Annual Review of Political Science* 22, no. 1 (May 2019): 343–360. https://doi.org/10.1146/annurev-polisci-050317-070830.

Koubi, Vally, Gabriele Spilker, Tobias Böhmelt, and Thomas Bernauer. “Do Natural Resources Matter for Interstate and Intrastate Armed Conflict?” *Journal of Peace Research* 51, no. 2 (March 2014): 227–243. https://doi.org/10.1177/0022343313493455.

Landais, Emanuelle. “Desalination: Facts and procedures.” *Gulf News*, June 15, 2009. https://gulfnews.com/uae/environment/desalination-facts-and-procedures-1.72059

Luomi, Mari. “The International Relations of the Green Economy in the Gulf – Lessons from the UAE’s State-led Energy Transition.” *The Oxford Institute for Energy Studies, OIES PAPER: MEP* 12 (May 2015). https://doi.org/10.26889/9781784670313.

Masdar. “Al Dhafra Solar PV.” Accessed April 25, 2023. https://masdar.ae/en/Masdar-Clean-Energy/Projects/Al-Dhafra-Solar-PV.

Masdar. “Shams.” Accessed April 25, 2023. https://masdar.ae/Masdar-Clean-Energy/Projects/Shams.

MBRSIC. “A History of the Solar Park.” Accessed April 25, 2023. https://mbrsic.ae/en/about/mohammed-bin-rashid-al-maktoum-solar-park/

McDonnell, Rachael, A. “Circulations and Transformations of Energy and Water in Abu Dhabi’s Hydrosocial Cycle.” *Geoforum; Journal of Physical, Human, and Regional Geosciences* 57, (November 2014): 225–233. https://doi.org/10.1016/j.geoforum.2013.11.009.

Meierding, Emily. “Dismantling the Oil Wars Myth.” *Security Studies* 25, no. 2 (2016): 258–288. https://doi.org/10.1080/09636412.2016.1171968.

Meierding, Emily. *The Oil Wars Myth: Petroleum and the Causes of International Conflict*. Ithaca: Cornell University Press, 2020.

Mezher, Toufic, Hassan Fath, Zeina Abbas, and Arslan Khaled. “Techno-economic assessment and environmental impacts of desalination technologies.” *Desalination* 266, no 1–3 (January 2011): 263–273. https://doi.org/10.1016/j.desal.2010.08.035.

Mildner, Stormy-Annika, Gitta Lauster, and Wiebke Wodni. “Scarcity and Abundance Revisited: A Literature Review on Natural Resources and Conflict.” *International Journal of Conflict and Violence* 5, no. 1 (2011): 155–172. https://doi.org/10.4119/IJCV-2852.

MOCCAE. “About the Ministry.” Accessed April 11, 2023. https://www.moccae.gov.ae/en/about-ministry/about-the-ministry.aspx.

MOEI. “UAE National Energy Strategy 2050.” Presentation for CEM Long Term Energy Scenarios. Accessed April 27, 2023. https://www.irena.org/-/media/Files/IRENA/Agency/Webinars/UAE-

Mokri, Alaeddine, Mona Aal Ali, and Mahieddine Emziane. “Solar Energy in the United Arab Emirates: A Review.” *Renewable and Sustainable Energy Reviews* 28 (December 2013): 340–375. https://doi.org/10.1016/j.rser.2013.07.038.

Morrissette, Jason, and Douglas Borer. “Where Oil And Water Do Mix: Environmental Scarcity and Future Conflict in the Middle East and North Africa.” *Parameters: Journal of the US Army War College* 34, no. 4 (Winter 2004): 86–101. https://doi.org/10.55540/0031-1723.2223.

Murad, Ahmed. “An Overview of Conventional and Non-Conventional Water Resources in Arid Region: Assessment and Constrains of the United Arab Emirates (UAE).” *Journal of Water Resource and Protection* 2, no. 2 (February 2010): 181–190. https://doi.org/10.4236/jwarp.2010.22020

Murad, Ahmed, Hind Al Nuaimi, and Muna Al Hammadi. “Comprehensive Assessment of Water Resources in the United Arab Emirates (UAE).” *Water Resources Management* 21, no. 9 (2006): 1449–63. https://doi.org/10.1007/s11269-006-9093-4.

Nkansah-Dwamena, Ernest, and Hyunsoo Yoon. “Why is sub-Saharan Africa an attractive destination to foreign land grabbers? Evidence from country characteristics.” *African Development Review* 32, no. 2 (June 2022): 280–292. https://doi.org/10.1111/1467-8268.12632.

Ramachandran, Tholkappiyan, Abdel-Hamid Mourad, Fathalla Hamed. “A Review on Solar Energy Utilization and Projects: Development in and around the UAE.” *Energies* 15, no. 10 (2022), 3754. https://doi.org/10.3390/en15103754.

Reuters. “UAE asks state entities to buy local in food security push.” December 11, 2022. https://www.reuters.com/world/middle-east/uae-asks-state-entities-buy-local-food-security-push-minister-2022-12-11/.

Ritchie Hannah, Max Roser. “Electricity mix.” United Arab Emirates: Energy Country Profile. Our World in Data. Accessed April 24, 2023. https://ourworldindata.org/energy/country/united-arab-emirates#what-sources-does-the-country-get-its-energy-from.

Rizk, Zein, and Abdulrahman Alsharhan. “Water Resources in the United Arab Emirates.” *Developments in Water Science* 50 (2003): 245–264. https://doi.org/10.1016/s0167-5648(03)80022-9.

Robbins, Paul. *Political Ecology: A Critical Introduction*. Hoboken, New Jersey: Wiley-Blackwell, 2012.

Ross, Michael. “What Have We Learned about the Resource Curse?” *Annual Review of Political Science* 18, (May 2015): 239–259. https://doi.org/10.1146/annurev-polisci-052213-040359.

Saif, Omar, Toufic Mezher and Hassan Arafat, “Water security in the GCC countries: challenges and opportunities.” *Journal of Environmental Studies and Sciences* 4, no. 4 (December 2014): 329–346. https://doi.org/10.1007/s13412-014-0178-8.

Salehyan, Idean, and Cullen Hendrix. “Climate Shocks and Political Violence.” *Global Environmental Change: Human and Policy Dimensions* 28, (September 2014): 239–250. https://doi.org/10.1016/j.gloenvcha.2014.07.007.

Salimi, Mohsen, Morteza Hosseinpour, Tohid Borhani. “Analysis of Solar Energy Development Strategies for a Successful Energy Transition in the UAE.” *Processes* 2022, no. 10, 1338 (July 2022). https://doi.org/10.3390/pr10071338.

San Diego County Water Authority. “Desal Proces.” Seawater Desalination. Accessed April 12, 2023. https://www.sdcwa.org/your-water/local-water-supplies/seawater-desalination/.

Schneider, Mindi, Philip McMichael, “Deepening, and repairing, the metabolic rift.” *Journal of Peasant Studies* 37, no. 3 (July 2010): 461–484. https://doi.org/10.1080/03066150.2010.494371.

Schilirò, Daniele. “Diversification and Development of the United Arab Emirates’ Economy.” *Journal of Applied Economic Sciences* 24 (August 2013): 228–239. https://www.ceeol.com/search/article-detail?id=13331.

Selby, Jan, Omar Dahi, Christiane Fröhlich, and Mike Hulme. “Climate Change and the Syrian Civil War Revisited.” *Political Geography* 60, (September 2017): 232–244. https://doi.org/10.1016/j.polgeo.2017.05.007.

Sgouridis, Sgouris, Steve Griffiths, Scott Kennedy, Arslan Khalid, Natalia Zurita. “A sustainable energy transition strategy for the United Arab Emirates: Evaluation of options using an Integrated Energy Model.” *Energy Strategy Reviews* 2, no. 1 (June 2013): 8–18. https://doi.org/10.1016/j.esr.2013.03.002.

Shahin, Suzan, and Mohammed Salem. “The Challenges of Water Scarcity and the Future of Food Security in the United Arab Emirates (UAE).” *Natural Resources and Conservation* 3, no. 1 (2015): 1–6. https://doi.org/10.13189/nrc.2015.030101.

Smajgl, Alex, John Ward, and Lucie Pluschke. “The Water–Food–Energy Nexus – Realising a New Paradigm.” *Journal of Hydrology* 533 (February 2-16): 533–540. https://doi.org/10.1016/j.jhydrol.2015.12.033.

Smith, Benjamin, and David Waldner. *Rethinking the Resource Curse*. Cambridge, England: Cambridge University Press, 2021.

Sultan, Hanif. “Desalination Plants in the Emirate of Abu Dhabi.” In *History, Development and Management of Water Resources – Volume II*, edited by International Editorial Board, 158–176. Oxford: EOLSS Publishers, 2010.

Szabo, Sylvia. “The Water Challenge in the UAE.” *Dubai School of Government Policy Brief*, no. 29 (December 2011). https://eprints.soton.ac.uk/376548/1/DSG%2520Policy%2520Brief%252029%2520English.pdf.

Taryam, Abdullah Omran. *The Establishment of the United Arab Emirates: 1950-85*. London: Croom Helm, 1987.

Tsai, I-Tsung. “Political Economy of Energy Policy Reforms in the Gulf Cooperation Council: Implications of Paradigm Change in the Rentier Social Contract.” *Energy Research & Social Science* 41, (July 2018): 89–96. https://doi.org/10.1016/j.erss.2018.04.028.

U.AE. “Barakah Nuclear Energy Plant.” Nuclear energy. Last modified March 1, 2023. https://u.ae/en/information-and-services/environment-and-energy/water-and-energy/types-of-energy-sources/nuclear-energy.

U.AE. “UAE Energy Strategy 2050,” Accessed 24 April 2023. https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/uae-energy-strategy-2050.

U.AE. “Environmental challenges.” February 7, 2023. https://u.ae/en/information-and-services/environment-and-energy/environmental-challenges-in-the-uae.

U.AE. “National Food Security Strategy 2051,” Accessed May 6, 2023. https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/national-food-security-strategy-2051

U.AE. “Solar Energy.” Last modified May 17, 2022. https://u.ae/en/information-and-services/environment-and-energy/water-and-energy/types-of-energy-sources/solar-energy

U.AE. “The UAE Water Security Strategy 2036.” Accessed April 11, 2023. https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/the-uae-water-security-strategy-2036.

U.AE. “Water.” Accessed April 6, 2023. https://u.ae/en/information-and-services/environment-and-energy/water-and-energy/water-.

UN Water. “Water, Food and Energy.” Accessed December 17, 2022. https://www.unwater.org/water-facts/water-food-and-energy.

Uppal, Rachna. “UAE's non-oil foreign trade jumps 17% in 2022.” *Reuters*, February 6, 2023. https://www.reuters.com/markets/uaes-non-oil-foreign-trade-jumps-17-2022-2023-02-06/.

Webster, Nick. “UAE outlines plan to increase domestic food production and consumption.” *The National News*, March 22, 2023.

https://www.thenationalnews.com/uae/2023/03/22/uae-outlines-plan-to-increase-domestic-food-production-and-consumption/.

Woertz, Eckart. *Oil for Food: The Global Food Crisis and the Middle East*. London: Oxford University Press, 2015. https://doi.org/10.1146/annurev.energy.32.041006.101434.

Woertz, Eckart. “The Governance of Gulf Agro-Investments.” *Globalizations* 10, no. 1 (2013): 87–104. http://dx.doi.org/10.1080/14747731.2013.760932.

Wolf, Aaron. ““Water Wars” and Water Reality: Conflict and cooperation along international waterways.” In *Environmental Change, Adaptation, and Security*, edited by S. C. Lonergan, 251–265. Dordrecht: Springer,1999.

Young, Karen. The Political Economy of Energy, Finance and Security in the United Arab Emirates: Between the Majilis and the Market. Basingstoke: Palgrave Macmillan, 2014.

Zubari, Waleed. “Water Security in the GCC Countries.” In *Water and Food Security in the Arabian Gulf*, edited by Markaz al-Imārāt lil-Dirāsāt wa-al-Buḥūth al-Istirātījīyah, 81–101. Abu Dhabi: The Emirates Center for Strategic Studies and Research, 2013.