Locating Sustainable Extraction: A Comparative Study of Lithium in Jujuy, Argentina & Nevada, USA

A thesis submitted in partial fulfillment of the requirements for a Degree of Bachelor of Arts with Honors in International and Public Affairs

Lena S. Hansen
Brown University
Providence, RI
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Primary Thesis Advisor: Professor Deborah Gordon
Secondary Thesis Advisor: Professor Geri Augusto
Honors Seminar Instructor: Professor Claudia Elliott

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Deborah Gordon, Thesis Advisor

Date April 14, 2025

Geri Augusto, Second Reader

Approved by

Date _____

Professor Nicole Pangborn
Director, IAPA Honors Program

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ABSTRACT

The global shift toward decarbonization presents a paradox: minerals essential for renewable energy are obtained through processes that often reproduce ecological degradation and socioeconomic inequality, ultimately undermining sustainable development goals. As demand for these "transition minerals" grows, new regions are transformed into extractive frontiers. This study examines how the spatial relationship between extraction sites and consumption markets shapes sustainability outcomes. Through comparative analysis of lithium operations in Jujuy, Argentina and Nevada, United States, I investigate whether extraction dynamics change when resources are procured near consumption centers. Evidence indicates that proximity between extraction and consumption enhances sustainability across environmental, economic, and social dimensions. This geographic integration cultivates feedback mechanisms that promote responsible resource governance through improved water management, beneficial fiscal structures, and meaningful stakeholder engagement. Where extraction occurs matters. As nations pursue energy transition agendas, this research illuminates how reconfigured extraction-consumption geographies can minimize the reproduction of exploitative patterns, and plan for sustainable supply chain development. In an era of globalized production networks, this study contributes to efforts to re-materialize and spatialize the energy transition by critically examining which communities and landscapes bear the costs of decarbonization.

Keywords: Transition minerals; lithium extraction; sustainability; energy transition; core-periphery relations; resource governance; global production networks; green economy; sustainable development

Cover Image: Earthworks. "Lithium mine at Salinas Grandes salt desert Jujuy province, Argentina." Flickr. Accessed April 11, 2025.

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ABBREVIATIONS

UN— United Nations

BEV — Battery Electric Vehicle

EV— Electric Vehicle

SDG— Sustainable Development Goal

OECD— Organization for Economic Cooperation and Development

LIB— lithium-ion battery

Li— lithium

LCE— lithium carbonate equivalent

EU — European Union

IEA— International Energy Agency

NEPA— National Environmental Policy Act

BLM— Bureau of Land Management

DLE— Direct Lithium Extraction

JEMSE— Jujuy Energía y Minería Sociedad de Estado (Jujuy Energy and Mining State Society)

UGAMP— Unidad Ambiental de Gestión Minera Provincial (Unit of Environmental Management)

CHAPTER ONE: TRANSITION MINERALS AND THE GREEN DILEMMA

As we reshape how we power our societies and economies, we cannot replace one dirty, exploitative, extractive industry with another dirty, exploitative, extractive industry. The race to net zero cannot trample over the poor.

—Antonio Guterres, Secretary General United Nations[1]

Introduction

In pursuit of sustainable development and a "green energy transition," our globalized economy risks exacerbating unjust relationships of extraction and exploitation. While global investment in renewable energy has surpassed fossil fuel spending, with clean energy receiving nearly double the investment as of 2024,[2] the benefits and drawbacks of this growth are not distributed equally across different regions of the world. Investment in clean energy, defined as non-carbon-based energy such as wind, solar, or hydropower, marks a global transition towards renewable energies and mass electrification. This energy transition is aligned with sustainability, defined by the United Nations as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."[3] As such, these development projects are associated with a "green" or "greening" agenda, that couples tackling these ecological challenges with avenues for global economic growth and poverty

[1] "Secretary-General's Remarks for the Launch of the Panel on Critical Energy Transition Minerals [As Delivered] | United Nations Secretary-General," accessed December 9, 2024, https://www.un.org/sg/en/content/sg/statement/2024-04-26/secretary-generals-remarks-for-the-launch-of-the-panel-critical-energy-transition-minerals-delivered.

[2] "World Energy Investment 2024," *International Energy Agency*, 2024.

[3] "THE 17 GOALS | Sustainable Development," accessed December 9, 2024, https://sdgs.un.org/goals.

reduction.[4] Decarbonization refers to decreasing carbon emissions to limit global warming above the 1.5 degree C tipping point,[5] as exhibited by the commitment to meet the "Net Zero Emissions by 2050" goal set by the United Nations (UN) Net Zero Coalition.[6]

These commitments require innovative technologies, including energy storage systems in the power sector and mobile battery electric vehicles (BEV) to decarbonize transport. During the 2021 Conference of Parties (COP26), over 100 countries, cities, financial institutions and transnational corporations agreed to 100% zero-emission vehicles target by 2040,[7] indicating widespread adoption of battery technologies and economic incentives to increase consumption of these technologies. This technology sector requires immense quantities of minerals, with their applications ranging from battery

[4] "Sustainability | United Nations," accessed October 7, 2024, https://www.un.org/en/academic-impact/sustainability.

[5] 1.5 degrees Celsius above pre-industrial temperature levels. This "tipping point" was determined by the Intergovernmental Panel on Climate Change (IPCC), defined as a critical threshold that, when exceeded, can cause a system (climate) to reorganize in a significant and often irreversible way.

[6] Peter Greim, A. A. Solomon, and Christian Breyer, "Assessment of Lithium Criticality in the Global Energy Transition and Addressing Policy Gaps in Transportation," *Nature Communications* 11, no. 1 (September 11, 2020): 4570, https://doi.org/10.1038/s41467-020-18402-y..

[7] Aleksandra Natalia Wojewska et al., "The Criticality of Lithium and the Finance-Sustainability Nexus: Supply-Demand Perceptions, State Policies, Production Networks, and Financial Actors," *The Extractive Industries and Society* 17 (March 1, 2024): 101393, https://doi.org/10.1016/j.exis.2023.101393.

performance to key inputs for electrical conduction.[8] These mineral elements include nickel, graphite, cobalt, rare earth elements, and lithium; total demand is expected to double by 2040.[9]

This growth of demand in the last few years has been largely driven by the energy transition (see figure 1.1), therefore, these minerals are defined as transition minerals.[10] These minerals must be extracted and refined in large quantities to provide for burgeoning demand, but the extractive activity occurs on local levels, with impacts for the communities situated at and near the frontlines of extraction.[11] Mining poses risks to marginalized frontline communities, particularly indigenous groups.[12] In a study conducted in

[8] "Secretary-General's Remarks for the Launch of the Panel on Critical Energy Transition Minerals [As Delivered] | United Nations Secretary-General," accessed December 9, 2024, https://www.un.org/sg/en/content/sg/statement/2024-04-26/secretary-generals-remarks-for-the-launch-of-the-panel-critical-energy-transition-minerals-delivered; Benjamin K. Sovacool et al., "Sustainable Minerals and Metals for a Low-Carbon Future," *Science* 367, no. 6473 (January 3, 2020): 30–33, https://doi.org/10.1126/science.aaz6003.

[9] International Energy Agency, *Critical Minerals Market Review 2023* (OECD, 2023), https://doi.org/10.1787/9cdf8f39-en.

[10] The term "transition minerals" and the term "critical minerals" are dynamic labels, which are defined differently by different actors according to political and economic interests. I use "transition minerals" throughout this thesis to refer to minerals that are of increasing interest on global markets due to their essentiality in the energy transition. This is narrower than "critical minerals", which include those for military or other wider economic purposes.

[11] Sophia Kalantzakos, "The Race for Critical Minerals in an Era of Geopolitical Realignments," *The International Spectator* 55, no. 3 (July 2, 2020): 1–16, https://doi.org/10.1080/03932729.2020.1786926; Greim, Solomon, and Breyer, "Assessment of Lithium Criticality in the Global Energy Transition and Addressing Policy Gaps in Transportation"; John D. Graham, John A. Rupp, and Eva Brungard, "Lithium in the Green Energy Transition: The Quest for Both Sustainability and Security," *Sustainability* 13, no. 20 (October 13, 2021): 11274, https://doi.org/10.3390/su132011274; Jiri Sterba et al., "Lithium Mining: Accelerating the Transition to Sustainable Energy," *Resources Policy* 62 (August 1, 2019): 416–26, https://doi.org/10.1016/j.resourpol.2019.05.002.

[12] While this thesis discusses indigenous communities at the frontlines of extraction, it is not the focus. There is a vast amount of literature produced by indigenous groups and individuals on extraction, land dispossession and epistemologies. There is a gap in the literature, and the need for more of these works, however this is not the gap that this thesis looks to address. For more, see: Traci Brynne Voyles, *Wastelanding: Legacies of Uranium Mining in Navajo Country* (University of Minnesota Press, 2015), http://www.jstor.org.revproxy.brown.edu/stable/10.5749/j.ctt155jmrg. Kyle Whyte, "Indigenous Environmental Justice, Renewable Energy Transition, and the Infrastructure of Sovereignty," in *Environmental Justice in North America*, by Paul C. Rosier, 1st ed. (New York: Routledge, 2023), 307–30, https://doi.org/10.4324/9781003214380-13. Winona LaDuke, *All Our Relations: Native Struggles for Land and Life* (Chicago: Haymarket Books, 2016).

2022, more than half of five-thousand transitional mineral sites were located on indigenous[13] land.[14] These frontline communities are frequently subjected to gross human rights violations such as horrific working conditions, environmental pollution, land dispossession and violence. Instances of these abuses are documented across the world, including but not limited to: exploitative child labor practices and violent extortion to extract cobalt in the Democratic Republic of Congo;[15] severe pollution for Indonesian communities living near nickel mining and smelting activity;[16] and the violation of indigenous water rights in the salt flats of South America in the name of lithium extraction.[17]

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[13] Indigenous land refers to territories traditionally inhabited, used, or occupied by Indigenous peoples before colonization or establishment of state boundaries, to which they maintain rights based on historical occupation, cultural connection, and spiritual relationship. This definition and parameters of this are heavily contested and disputed by various scholars and activists. For more, see: "United Nations Declaration on the Rights of Indigenous Peoples," Pub. L. No. Resolution 61/295 (2007), https://www.un.org/development/desa/indigenouspeoples/wp-content/uploadshttps://www.un.org/development/desa/indigenouspeoples/wp-content/uploads/sites/19/2018/11/UNDRIP_E_web.pdf./sites/19/2018/11/UNDRIP_E_web.pdf.; Jérémie Gilbert, *Indigenous Peoples' Land Rights under International Law: From Victims to Actors*, 1st ed (Leiden: BRILL, 2007).

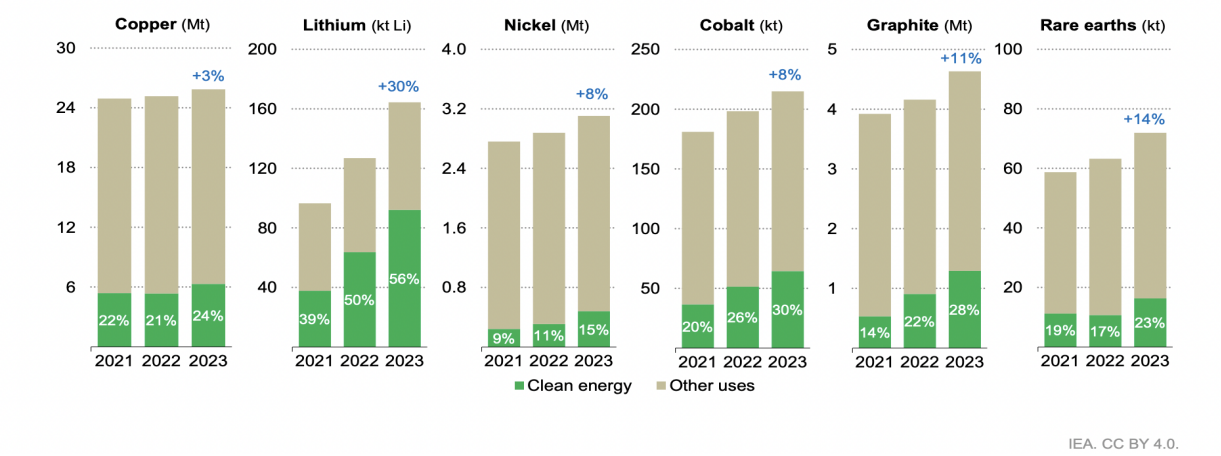
[14] John R. Owen et al., "Energy Transition Minerals and Their Intersection with Land-Connected Peoples," *Nature Sustainability* 6, no. 2 (February 2023): 203–11, https://doi.org/10.1038/s41893-022-00994-6.

[15] Siddharth Kara, *Cobalt Red: How the Blood of the Congo Powers Our Lives*, First edition (New York, NY: St. Martin's Press, 2023).

[16] Press Release, "Indonesia: Huge Nickel Project Driving Climate, Rights, Environmental Harms," *Climate Rights International* (blog), January 17, 2024, https://cri.org/indonesia-huge-nickel-project-driving-climate-rights-environmental-harms/; Mads Barbesgaard and Andy Whitmore, "'Blood on the Floor:' The Nickel Commodity Frontier and Inter-Capitalist Competition under Green Extractivism," *Journal of Political Ecology* 30, no. 1 (May 22, 2024), https://doi.org/10.2458/jpe.5458.

[17] Beatriz Bustos-Gallardo, Gavin Bridge, and Manuel Prieto, "Harvesting Lithium: Water, Brine and the Industrial Dynamics of Production in the Salar de Atacama," *Geoforum* 119 (February 1, 2021): 177–89, https://doi.org/10.1016/j.geoforum.2021.01.001; James J. A. Blair et al., "The 'Alterlives' of Green Extractivism: Lithium Mining and Exhausted Ecologies in the Atacama Desert," *International Development Policy | Revue Internationale de Politique de Développement*, no. 16 (April 6, 2023), https://doi.org/10.4000/poldev.5284; Felix Malte Dorn and Felix Malte Dorn, "Changing Territorialities in the Argentine Andes: Lithium Mining at Salar de Olaroz-Cauchari and Salinas Grandes," *Die ERDE*, 2021, 1–17, https://doi.org/10.12854/erde-2021-515; Xuezhi Yang et al., "Lithium Pollution and Its Associated Health Risks in the Largest Lithium Extraction Industrial Area in China," *Environmental Science & Technology* 58, no. 26 (July 2, 2024): 11637–48, https://doi.org/10.1021/acs.est.4c00225.

Figure 1.1— Demand outlook for selected key transition minerals 2021-2023 [18]



Source: International Energy Agency, Global Critical Minerals Outlook 2024

Note: units of measurement vary between metric ton and kiloton are denoted next to each element

The "green" energy transition seeks to increase global sustainability and provide economic development opportunities, however the demand for transition minerals presents a sustainability and climate justice problem.[19] While racing towards a decarbonized economy and "net-zero," the mining of these minerals threatens the viability of the Sustainable Development Goals (SDGs) promoted by the

[18] Notes: Rare earths include the four magnetic elements: neodymium, praseodymium, dysprosium and terbium. Demand for clean energy applications includes consumption for low-emissions power generation, EV and battery storage, grid networks and hydrogen technologies (IEA).

[19] Anabel Marín and Daniel Goya, "Mining—The Dark Side of the Energy Transition," *Environmental Innovation and Societal Transitions* 41 (December 2021): 86–88, https://doi.org/10.1016/j.eist.2021.09.011.

United Nations. Transition mineral mining has violated SDGs including Goal 3 on health, Goal 6 on water access, Goal 8 on decent work, and Goal 12 on responsible consumption and production.[20] Some politicians, activists and scholars call for a socially just transition, demanding that the existing patterns of global inequality are not worsened by this "greening" agenda.[21] In global extraction economies, sites of consumption (purchase of finished goods) and production (value-added processes e.g. refining, processing, packaging) are frequently dislocated (meaning geographically distant) from the regions where extraction occurs. This dislocation results in extraction sites bearing an unequal ecological burden,[22] a product of uneven development,[23] as these areas do not receive economic or long-term development advantages.[24] Additionally, mineral extraction reinforces systemic global inequality, enabling wealthy nations to amass wealth at the expense of poorer regions. These global patterns are being actively perpetuated through growth in the green economy.

While investment in EVs and renewable energy has increased globally, geographically, the majority remains concentrated in wealthier countries, with 85% of investment occurring in OECD[25]

[20] "THE 17 GOALS | Sustainable Development."

[21] Axel Anlauf, "Greening the Imperial Mode of Living? Socio- Ecological (in)Justice, Electromobility, and Lithium Mining in Argentina," in *Fairness and Justice in Natural Resource Politics*, ed. Melanie Pichler, Routledge Explorations in Environmental Studies (London ; New York: Routledge, Taylor & Francis Group, 2017), 164–80; Graham, Rupp, and Brungard, "Lithium in the Green Energy Transition"; Blair et al., "'The 'Alterlives' of Green Extractivism."

[22] Christian Dorninger et al., "Global Patterns of Ecologically Unequal Exchange: Implications for Sustainability in the 21st Century," *Ecological Economics* 179 (January 2021): 106824, https://doi.org/10.1016/j.ecolecon.2020.106824.

[23] Smith, N. *Uneven Development: Nature, Culture, and the Production of Space*. Oxford: Blackwell, 1984.

[24] Raul Prebisch, "The Economic Development of Latin America and Its Principal Problems.," 1962.

[25] Organization for Economic Cooperation and Development, includes 38 countries, see: "Members and Partners," OECD, accessed March 18, 2025, https://www.oecd.org/en/about/members-partners.html.

member countries, with China[26] as an exception (see figure 1.2). These consuming countries often do not bear the negative consequences of transition mineral extraction, yet benefit from the economic incentives and environmental benefits of renewables, EVs and other technologies.[27] Local communities at sites of extraction are frequently disregarded in decision making processes while multinational corporations and mining industries extract raw commodities for global markets.[28] The prioritization of raw material extraction for export markets is positioned by scholars[29] as "diametrically opposed" to the sustainability agenda being pursued by the green transition, as it worsens environmental, social and

[26] China plays an integral role in current supply and demand for transition minerals globally. China is responsible for a huge majority of global renewable energy investment and electric vehicle demand (see figure 1.3). China is the dominant world refiner and consumer for transition minerals used across the globe, and the leading manufacturer of finished renewable technologies and EVs. Chinese companies have vast investment in extraction ventures spanning from Africa to South America, the Arctic and Australia in addition to mining their own domestic deposits. China's dominance and control over supply chains is an important factor that has incentivized countries in North America and Europe to expand extraction frontiers within borders. For studies on lithium in China see: Yang et al., "Lithium Pollution and Its Associated Health Risks in the Largest Lithium Extraction Industrial Area in China"; Deng-hong Wang et al., "Research and Exploration Progress on Lithium Deposits in China," *China Geology* 3, no. 1 (March 1, 2020): 137–52, https://doi.org/10.31035/cg2020018; Song Hu et al., "Forecast and Suggestions on The Demand of Lithium, Cobalt, Nickel and Manganese Resources in China's New Energy Automobile Industry," *IOP Conference Series: Earth and Environmental Science* 769, no. 4 (May 1, 2021): 042018, https://doi.org/10.1088/1755-1315/769/4/042018; Jian Feng Song et al., "Lithium Extraction from Chinese Salt-Lake Brines: Opportunities, Challenges, and Future Outlook," *Environmental Science: Water Research & Technology* 3, no. 4 (2017): 593–97, https://doi.org/10.1039/C7EW00020K.

[27] Ulrich Brand and Markus Wissen, "Crisis and Continuity of Capitalist Society-Nature Relationships: The Imperial Mode of Living and the Limits to Environmental Governance," *Review of International Political Economy* 20, no. 4 (August 1, 2013): 687–711, https://doi.org/10.1080/09692290.2012.691077.

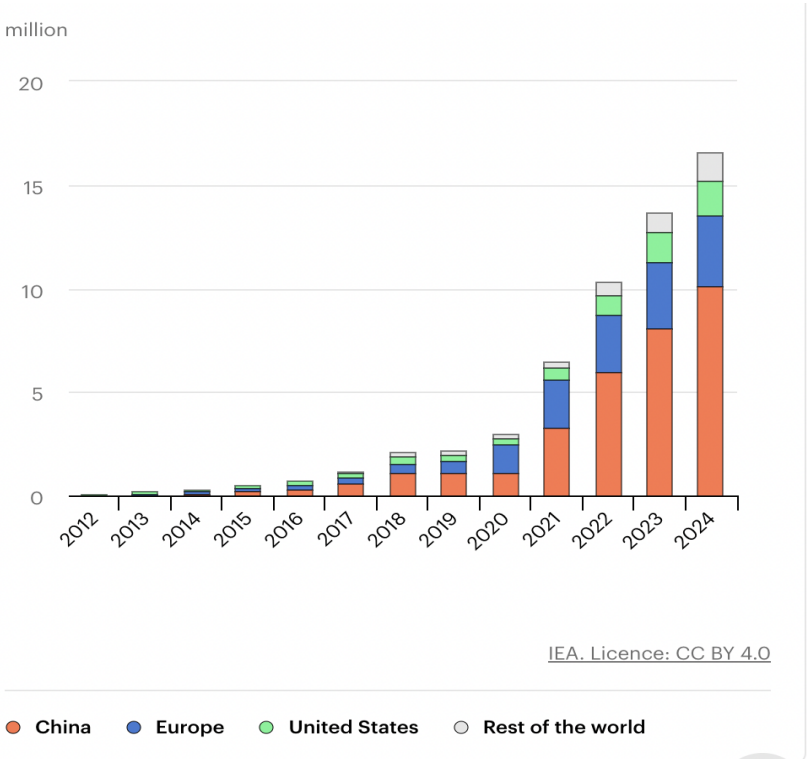
[28] Tom Perreault, "Dispossession by Accumulation? Mining, Water and the Nature of Enclosure on the Bolivian Altiplano: Antipode," *Antipode* 45, no. 5 (November 2013): 1050–69, https://doi.org/10.1111/anti.12005.

[29] It is important to note that notions of sustainability and extraction are not diametrically opposed in all cultures and communities. A vast body of traditional knowledge exists across the globe, where communities rely upon the extraction of raw materials while simultaneously prioritizing the tenants of sustainability and preserving for future generations. For more on this, see: Connell, Robert. "Maroon Ecology: Land, Sovereignty, and Environmental Justice." *The Journal of Latin American and Caribbean Anthropology* 25, no. 2 (June 2020): 218–35. https://doi.org/10.1111/jlca.12496.

economic global inequality.[30] In April, United Nations Secretary-General Antonio Guterres publicly addressed this inequality, by inaugurating a new body to the UN: the "Panel on Critical Energy Transition Minerals." This panel was introduced to govern increasing demand for these minerals and acknowledge that the burden of clean energy cannot fall on regions of the world with legacies of exploitation due to their abundance of these minerals. As such, growing attention has been placed on what locales, geographies and communities bear the costs of transition.

[30] Christopher Chagnon et al., "From Extractivism to Global Extractivism: The Evolution of an Organizing Concept," *Journal of Peasant Studies* 49 (May 9, 2022), https://doi.org/10.1080/03066150.2022.2069015.

Figure 1.2— Electric Vehicles Sales (millions) 2012-2024



Source: "Electric Vehicles" International Energy Agency

New extraction sites are emerging in North America and Europe (specifically for abundant minerals like lithium) due to geopolitical concerns about supply chains. As these new sites emerge, so does an intellectual and practical puzzle. In the case of lithium—a transition mineral with the fastest growing demand and natural abundance—new extraction frontiers are expanding in wealthier countries to supply lithium-ion batteries for domestic electric vehicle (EV) markets. These new sites of lithium extraction and battery production provide an opportunity to compare how dynamics of extraction may shift when sites are located within the same country that consumes the end-product (e.g. North America and Europe). Extraction frontiers are legitimized through development narratives that couple

sustainability with extraction,[31] presuming that extractive activity may be more sustainable in some locales than others.

To what extent does the locale of extraction impact sustainability? More specifically, to what extent do dynamics of extraction change when a commodity is extracted in the same locale that it is consumed? Locale of extraction, in this instance, refers to the geographic relationship between where raw resources are extracted, produced, and ultimately consumed.

I argue that the "locale of extraction" directly impacts the dynamics of extraction, and their sustainability. Meaning, when extraction occurs far from consumption, sustainability suffers. This spatial disconnect weakens economic incentives, regulatory oversight, and social accountability that would otherwise promote more responsible resource extraction methods. "Dynamics of extraction" encompasses everything about how natural resources become market commodities: ownership and control structures, profit distribution, resource intensity (water/energy usage), and impacts on local communities and ecosystems. I propose that when extraction primarily serves distant markets, dynamics of extraction foster less long-term sustainability. Conversely, when extraction primarily supports local production and domestic consumption, extraction develops with dynamics that are more conducive to sustainability. This geographic connection between extraction and consumption creates stronger feedback loops that favor environmentally and socially responsible resource management.

[31] Thea Riofrancos, "The Security–Sustainability Nexus: Lithium Onshoring in the Global North," *Global Environmental Politics* 23, no. 1 (2023): 20–41.

While measuring sustainability is a challenge, there are three pillars of sustainability that are widely accepted and reported:[32] environmental, economic and social. I find that locating sites of extraction closer to the regions of final consumption improves sustainability outcomes through the evaluation of extraction dynamics. Environmental sustainability improves through better water governance, ecological planning, and technological innovation. Economic sustainability improves through beneficial fiscal policy, decreased costs of transporting raw materials, and value-added production and manufacturing creation nearby to sites of extraction.[33] Social sustainability improves due to increased community support for mining projects, generated by increased community engagement and consultation, and economic opportunity generated by the industry development.

Ultimately, sustainability can be quantified by the long-term viability of extractive operation, as the abandonment of extraction sites results in the ecological destruction of land without any benefit for communities and can have devastating impacts both socially and economically. Sustainability, in the case of lithium extraction sites, is tied to the long-term viability of the operation, dependent on responsible management of natural resources, economic incentives and community engagement.[34]

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[32] Adisa Azapagic, "Developing a Framework for Sustainable Development Indicators for the Mining and Minerals Industry," *Journal of Cleaner Production*, SME's and Experiences with Environmental Management Systems, 12, no. 6 (August 1, 2004): 639–62, https://doi.org/10.1016/S0959-6526(03)00075-1.https://doi.org/10.1016/S0959-6526(03)00075-1Azapagic.

[33] Additionally, lower transport costs and risk provide incentive for firms to keep production chains nearby to extraction sites, limiting carbon emissions from transport and providing economic benefits to extractive regions.

[34] This phenomenon is exemplified by Nobel prize winning economist Elinor Ostrom's work with common resource management, in which she writes on managing common resources, finding that when communities are engaged in decision making processes and benefit from the management of resources, they maintain the longevity of the resource.

The purpose of this thesis is to uncover if, and to what extent, the locale of extraction has an impact on sustainability. As transition mineral mining threatens livelihoods and undermines global sustainability agendas, an empirical investigation into the relationship between extraction locale and sustainability is required. This study tests and extends theories of core-periphery models and extractivism and their applicability in predicting sustainability outcomes for emerging extraction frontiers that may be beyond the explanatory power of these theories. I develop a framework for evaluating sustainability though a political ecology framework and the three pillars discussed above. This study serves as a point of departure for future studies on both the political geographies and ecologies of extraction amidst the pursuit for global sustainability.

SIGNIFICANCE

Theoretical Significance

There are theoretical reasons to undertake this study. Firstly, this study contributes to a growing theoretical debate, which seeks to test theories such as, extractivism, core-periphery theory, and unequal exchange in contemporary contexts. Extractivist theory, pioneered by scholars in the 20th century, is derived from Latin American export-led raw material extraction economies with legacies of colonialism, such as Brazil, Argentina, Bolivia, Chile.[35] Extractivist economies export raw materials to sites of

[35] Albert Acosta, "Extractivism and and Neo Extractivism: Two Sides of the Same Curse," in *Beyond Development: Alternative Visions from Latin America* (Transnational Institute, 2011), 61–86; Eduardo Gudynas, "Extractivisms: Tendencies and Consequences," in *Reframing Latin American Development*, ed. Ronaldo Munck and Raúl Delgado Wise, 2018; Eduardo Gudynas, *Extractivismos: ecología y política de un modo de entender el desarrollo de la naturaleza*, Primera edición (Cochabamba, Bolivia: CEDIB, Centro de Documentación e Información Bolivia, 2015).

consumption, geographically, socially and economically distanced from the ecological limits of the local environment.[36] Extractivism builds upon "core-periphery" theory, which posits that when peripheral regions export their raw materials and surplus value to core (central) countries or regions, these extractive frontiers become trapped in a cycle of dependency. When peripheral areas primarily function as resource providers without developing value-added industries of their own, they remain economically dependent on raw material exports. This dependency prevents these regions from developing autonomous, diversified economies with local manufacturing and processing capabilities. Consequently, this extraction-focused development model fundamentally undermines the broader goals of sustainable development by limiting economic diversification, local wealth creation, and self-determination in resource-rich peripheral regions.[37]

These theories were derived from case studies in countries with legacies of colonial exploitation, ranging from countries of the African continent to South America. The overwhelming emphasis on colonial legacy within this field of study creates a need to investigate how extraction changes outside of the geographic and historical foundation that these theories rely upon. In an increasingly globalized world, scholars have argued that binary divisions between a "core" and a "periphery" are blurred.[38] This

[36] Dorninger et al., "Global Patterns of Ecologically Unequal Exchange."

[37] Fernando Henrique Cardoso, "The Consumption of Dependency Theory in the United States," *Latin American Research Review* 12, no. 3 (1977): 7–24, https://doi.org/10.1017/S0023879100030430; Prebisch, "The Economic Development of Latin America and Its Principal Problems."

[38] Kristina Dietz and Bettina Engels, "Contested Extractivism, Society and the State: An Introduction," in *Contested Extractivism, Society and the State*, ed. Bettina Engels and Kristina Dietz (London: Palgrave Macmillan UK, 2017), 1–19, https://doi.org/10.1057/978-1-137-58811-1_1.

study compares resource extraction patterns in two contrasting locations: one that fits the traditional "extractivist" model described in established theories, and another that operates outside these theoretical frameworks. By examining both a typical case and an exception, this research aims to test the boundaries of current theoretical understandings about resource extraction and global sustainability. It also explores the counterfactual to extractivist theory, positing that without legacies of extractivism and geographic dislocation of extraction from end consumption, that dynamics of extraction may cause sustainability outcomes to improve.

Secondly, this study adds to a growing body of literature that looks to address how we can meet the material demands of the energy transition (primarily the demand for transition minerals).[39] Amidst international recognition for the need to achieve a "just transition" that does not perpetuate existing power structures,[40] scholars and policymakers stressed the importance of accounting for where and how we source transition minerals. A growing body of scholarship addresses global value chains,[41] mineral supply chain management, and how we can globally achieve goals of a green economy. However, scholars have raised concerns about how electrification and globalized supply chains increasingly

[39] Ebru Susur and Emrah Karakaya, "A Reflexive Perspective for Sustainability Assumptions in Transition Studies," *Environmental Innovation and Societal Transitions* 39 (June 2021): 34–54, https://doi.org/10.1016/j.eist.2021.02.001.

[40] Anlauf, "Greening the Imperial Mode of Living? Socio- Ecological (in)Justice, Electromobility, and Lithium Mining in Argentina"; Facundo Martín, "Reimagining Extractivism: Insights from Spatial Theory," in *Contested Extractivism, Society and the State*, ed. Bettina Engels and Kristina Dietz (London: Palgrave Macmillan UK, 2017), 21–44, https://doi.org/10.1057/978-1-137-58811-1_2.

[41] Marion Werner and Jennifer Bair, "Global Value Chains and Uneven Development: A Disarticulations Perspective," *Chapters*, 2019, 183–98; Marion Werner, "Geographies of Production I: Global Production and Uneven Development," *Progress in Human Geography* 43, no. 5 (October 1, 2019): 948–58, https://doi.org/10.1177/0309132518760095.

"dematerialize" consumption.[42] As such, there is a need to "rematerialize" these technologies, by investigating *how* and *where* the material requirements of transition are being met.

Third and finally, this study contributes to a growing body of literature that looks to account for and evaluate sustainability.[43] Sustainability is often a vague and superficial descriptor, a term utilized by politicians, corporations and NGOs for specific agendas without practical measurement or accountability. As such, by focusing on the extractive dynamics of a mineral aligned with a "green extraction" agenda, this study has implications for how we conceptualize "greening agendas" and their efficacy.[44] Additionally, scholarship has increasingly sought to explore the upstream material inputs to globalized trade to account for global sustainability metrics. Authors writing on ecological economics and circular economies[45] stress how proximity and co-locating sites of production nearby to consumption can improve global sustainability within planetary boundaries.[46] Given these claims, this

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[42] Gavin Bridge, "Resource Triumphalism: Postindustrial Narratives of Primary Commodity Production," *Environment and Planning A: Economy and Space* 33, no. 12 (December 2001): 2149–73, https://doi.org/10.1068/a33190; Gavin Bridge, "Global Production Networks and the Extractive Sector: Governing Resource-Based Development," *Journal of Economic Geography* 8, no. 3 (May 1, 2008): 389–419, https://doi.org/10.1093/jeg/lbn00Gavin Bridge, "Material Worlds: Natural Resources, Resource Geography and the Material Economy," *Geography Compass* 3, no. 3 (May 2009): 1217–44, https://doi.org/10.1111/j.1749-8198.2009.00233.x.

[43] Anke Schaffartzik, Dominik Wiedenhofer, and Nina Eisenmenger, "Raw Material Equivalents: The Challenges of Accounting for Sustainability in a Globalized World," *Sustainability* 7, no. 5 (May 2015): 5345–70, https://doi.org/10.3390/su7055345.

[44] Teresa Kramarz, Susan Park, and Craig Johnson, "Governing the Dark Side of Renewable Energy: A Typology of Global Displacements," *Energy Research & Social Science* 74 (April 2021): 101902, https://doi.org/10.1016/j.erss.2020.101902.

[45] Julie Michelle Klinger, "Groundbreaking, without Breaking New Ground: Redesigning e-Waste Recycling Could Clean up the Supply Chain While Building the Foundations for a Hemispheric Green Future.," *NACLA Report on the Americas* 52, no. 2 (April 2, 2020): 158–64, https://doi.org/10.1080/10714839.2020.1768734.

[46] Ibrahim M. Algunaibet and Gonzalo Guillén-Gosálbez, "Life Cycle Burden-Shifting in Energy Systems Designed to Minimize Greenhouse Gas Emissions: Novel Analytical Method and Application to the United States," *Journal of Cleaner Production* 229 (August 20, 2019): 886–901, https://doi.org/10.1016/j.jclepro.2019.04.276; Will Steffen and Mark Stafford Smith, "Planetary Boundaries, Equity and Global Sustainability: Why Wealthy Countries Could Benefit from

study provides an opportunity to investigate claims of more "sustainably" produced lithium by countries like the US[47] and countries in the European Union. The viability of sustainable extraction remains hotly contested, even in wealthier countries and in the presence of "responsibility" or "sustainability agendas" where these ideals often fall short in practice.[48] The findings of this study will provide empirical groundings for primarily theoretical notions on how to achieve sustainability and propose a framework through which to holistically evaluate the multi-faceted nature of sustainability.[49]

Practical Significance

There are practical reasons to undertake this study. First, this study addresses urgent needs in the rapidly expanding global lithium, and transition mineral landscape. As extraction frontiers emerge across diverse environments—from Serbia to Portugal to Zimbabwe—evaluating and comparing extraction locales, what markets they provide for, becomes crucial for future frontier expansion. Given lithium's increasing demand and geographic abundance, this study provides insight for policymakers, firms, and stakeholders about where new extractive frontiers can and should expand.

More Equity," *Current Opinion in Environmental Sustainability*, Open issue, 5, no. 3 (September 1, 2013): 403–8, https://doi.org/10.1016/j.cosust.2013.04.007.

[47] Riofrancos, "The Security–Sustainability Nexus."

[48] Robin Broad, "Responsible Mining: Moving from a Buzzword to Real Responsibility," *The Extractive Industries and Society* 1, no. 1 (March 2014): 4–6, https://doi.org/10.1016/j.exis.2014.01.001; Roopali Phadke, "Green Energy Futures: Responsible Mining on Minnesota's Iron Range," *Energy Research & Social Science* 35 (January 2018): 163–73, https://doi.org/10.1016/j.erss.2017.10.036; Kathrin Böhling, Diego I. Murguía, and Julieta Godfrid, "Sustainability Reporting in the Mining Sector: Exploring Its Symbolic Nature," *Business & Society* 58, no. 1 (January 2019): 191–225, https://doi.org/10.1177/0007650317703658.

[49] The definitions of what constitutes sustainability, and who gets included in these agendas, are hotly contested. While this thesis subscribes to the notions presented by the UN and their SDGs, it is important to note that the measurement and evaluation of this concept throughout this thesis is heavily influenced by alternative epistemologies that engage with what the concept can look like on multiple scales, from mindset to global development agendas.

Secondly, as extractive frontiers expand, these industries impact more individuals and livelihoods. With a well-documented history of human rights abuses in the mining sector and environmental degradation, it is important to compare how these negative impacts shift and proliferate across geographic contexts. If there are ways to minimize the negative impacts of extractive industries, the findings of this study could be leveraged to institute policies and practices that could *save* and *improve* lives across the globe. If we fail to evaluate the how and where of extracting these transition minerals, we threaten the lives of millions who could be subjected to toxic industries and excess exploitation, and we undermine the validity of a sustainable green energy transition.

Thirdly, this study could have larger implications for the end-use of lithium-ion batteries, and the viability of battery recycling networks. While these technologies are currently emerging, this study could have implications for where recycling sites develop to maximize sustainability outcomes. Additionally, this study adds to a growing understanding that expanding extractive activity is always less sustainable than recycling.[50] As circular lithium economies are implemented and developed,[51] this study has practical applications for supplying lithium within ecological limits of local environments.

[50] Klinger, "Groundbreaking, without Breaking New Ground."

[51] Levke Albertsen et al., "Circular Business Models for Electric Vehicle Lithium-Ion Batteries: An Analysis of Current Practices of Vehicle Manufacturers and Policies in the EU," *Resources, Conservation and Recycling* 172 (September 1, 2021): 105658, https://doi.org/10.1016/j.resconrec.2021.105658.

RESEARCH DESIGN

Case Study as Method

I use the Case Study Method[52] to test current theories of extractivism and identify locale as a potential antecedent condition for (un)sustainable dynamics of extraction.[53] This method allows for an in-depth examination of how the locale of raw material extraction impacts the dynamics of extraction, and therefore sustainability in two contrasting settings. I use this method to answer: To what extent does the locale of extraction impact sustainability? More specifically, to what extent do dynamics of extraction change when a commodity is extracted in the same locale that it is consumed?

The case study method is particularly suited for this question because it allows exploration into how the initial variable, locale, shapes extraction dynamics through multiple intervening variables of interest. The case study method requires the historical context, which is crucial in understanding the development of extractive industries.[54] Historical context and timelines of extractive history greatly impact extraction dynamics, as exhibited in extractivist theory. For example, in countries in Europe and North America, there has been a decline in the number of extractive industries operating within borders due to higher wages, resulting in the offshoring of mineral extraction overseas. Conversely, for resource

[52] Robert K. Yin, *Case Study Research: Design and Methods*, 3rd ed, Applied Social Research Methods Series, v. 5 (Thousand Oaks, Calif: Sage Publications, 2003).

[53] Stephen Van Evera, *Guide to Methods for Students of Political Science* (Cornell University Press, 1997), http://www.jstor.org/stable/10.7591/j.ctvrf8bm7.

[54] Gavin Bridge and Ludger Gailing, "New Energy Spaces: Towards a Geographical Political Economy of Energy Transition," *Environment and Planning A: Economy and Space*, July 5, 2020, https://doi.org/10.1177/0308518X20939570.

rich countries, a history of colonial exploitation and violence has hindered economic development as exhibited in the Democratic Republic of Congo, preventing economic diversification from the violent extraction that is still present today.[55] Given the contemporary nature of the phenomenon, and the unclear boundaries between the phenomenon of extractivism and that context in which extraction occurs, a case study is an appropriate method.[56] The comparative case study method is well-suited to multi-scalar analysis, allowing an examination of how locale impacts dynamics of extractivism and therefore sustainability metrics. The case study method incorporates various types of data and analysis methods. This is particularly valuable given the complex nature of extraction dynamics, which involve quantitative aspects (e.g. water use, energy use, taxes) and qualitative elements (e.g., governance, policy, community engagement/support). This mixed methods approach is crucial to evaluating the three pillars of sustainability: environmental, economic, and social.

Why Lithium?

This thesis focuses on one key transition mineral— an element used for both energy storage and batteries—lithium (Li). I chose this mineral for three reasons. First, lithium has become a sought-after element in the 21st century and has the fastest growing demand compared to other transition minerals (see figure 1.1). It is an extremely lightweight and reactive element— it is used in a refined form as a cathode in lithium-ion batteries (LIBs).[57] LIB use ranges from energy storage (crucial for renewable

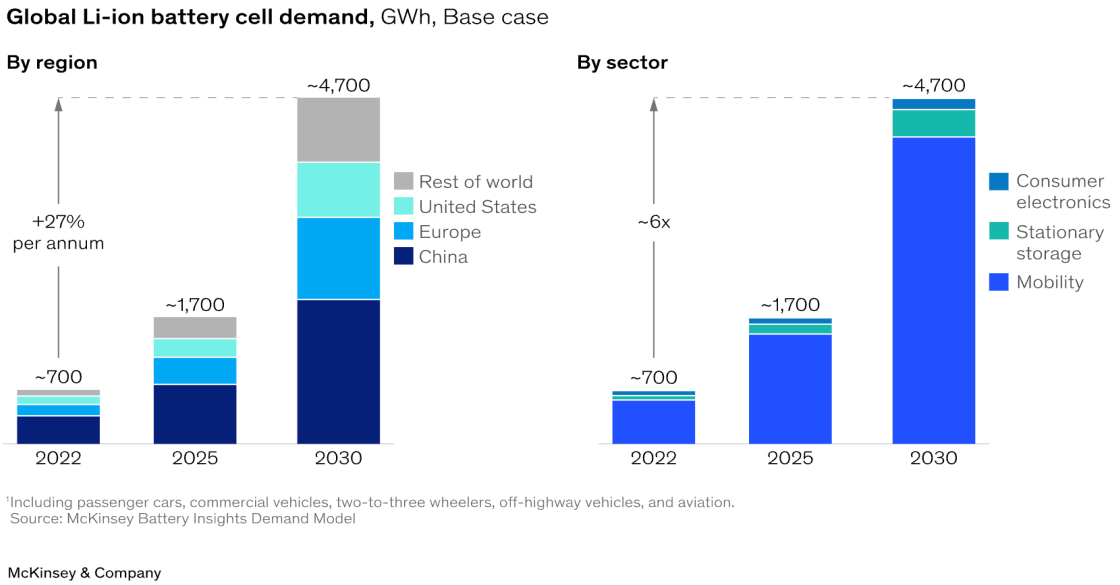
[55] Kara, *Cobalt Red*.

[56] Yin, *Case Study Research*.

[57] Hanjiro Ambrose and Jimmy O'Dea, "Electric Vehicle Batteries: Addressing Questions about Critical Materials and Recycling" (Union of Concerned Scientists, 2021), https://www.jstor.org/stable/resrep29545; Abby R. Goldman, Frank

energy technologies),[58] to electric vehicles[59] and to consumer electronics. Significant developments in global lithium markets have been driven by the surge in electric vehicle sales and projected demand will increase due to implementation of large-scale energy storage amidst implementation of renewable energy technologies (see figure 1.3).

Figure 1.3 — Global lithium-ion battery cell demand



Source: McKinsey & Company[60]

S. Rotondo, and Jessica G. Swallow, "The Electric Vehicle Battery Supply Chain," Lithium Ion Battery Industrial Base in the US and Abroad (Institute for Defense Analyses, 2019), https://www.jstor.org/stable/resrep22804.5.

[58] Greim, Solomon, and Breyer, "Assessment of Lithium Criticality in the Global Energy Transition and Addressing Policy Gaps in Transportation."

[59] Goldman, Rotondo, and Swallow, "The Electric Vehicle Battery Supply Chain."

[60] "Lithium-Ion Battery Demand Forecast for 2030 | McKinsey," accessed March 30, 2025, https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/battery-2030-resilient-sustainable-and-circular.

The energy transition, and policy incentives for the electric vehicle market have increased demand for lithium. These incentives span internationally, from the US Inflation Reduction Act of 2022 to Chinese subsidies for electric vehicle consumption, to EU mandate to make all vehicles sold electric by 2035. With no comparable battery alternatives yet, lithium is critical.[61] The International Energy Agency (IEA) predicts a 4,200% increase in global lithium demand from the 2022 level, by 2040, given the current market trajectories. This increasing demand for lithium has created concerns about shortages,[62] and geopolitical tensions surrounding who extracts, refines and produces lithium, and who consumes the end products. As such, it has become an increasingly important transition mineral, with the highest projected demand, and highlighted in recent legislation.[63]

Second, lithium reserves are geographically abundant worldwide (see figure 1.4). Lithium is a geopolitically strategic and geographically important resource for countries in Europe and the United States, who look to securitize supply chains. The current lithium production market is dominated by China, accounting for 57% of refining, followed by Chile (15%) and Argentina (13%). The International Energy Agency (IEA) determined the mineral as "high" geopolitical risk due to 85% of refining occurring in three top countries in 2024. High geopolitical risk in this case refers to risk of potential

[61] The level of lithium "criticality" could shift based on complex and interplaying factors such as transportation shifts, alternative mineral research, social pushback, and price fluctuation. For example, the World Bank only projects a 965% increase in demand by 2040. In any case, the projected demand increase for lithium is substantially higher than other transition minerals.

[62] Elsa A. Olivetti et al., "Lithium-Ion Battery Supply Chain Considerations: Analysis of Potential Bottlenecks in Critical Metals," *Joule* 1, no. 2 (October 11, 2017): 229–43, https://doi.org/10.1016/j.joule.2017.08.019; Amato Alessia et al., "Challenges for Sustainable Lithium Supply: A Critical Review," *Journal of Cleaner Production* 300 (June 1, 2021): 126954, https://doi.org/10.1016/j.jclepro.2021.126954.

[63] See: American Minerals Security Act

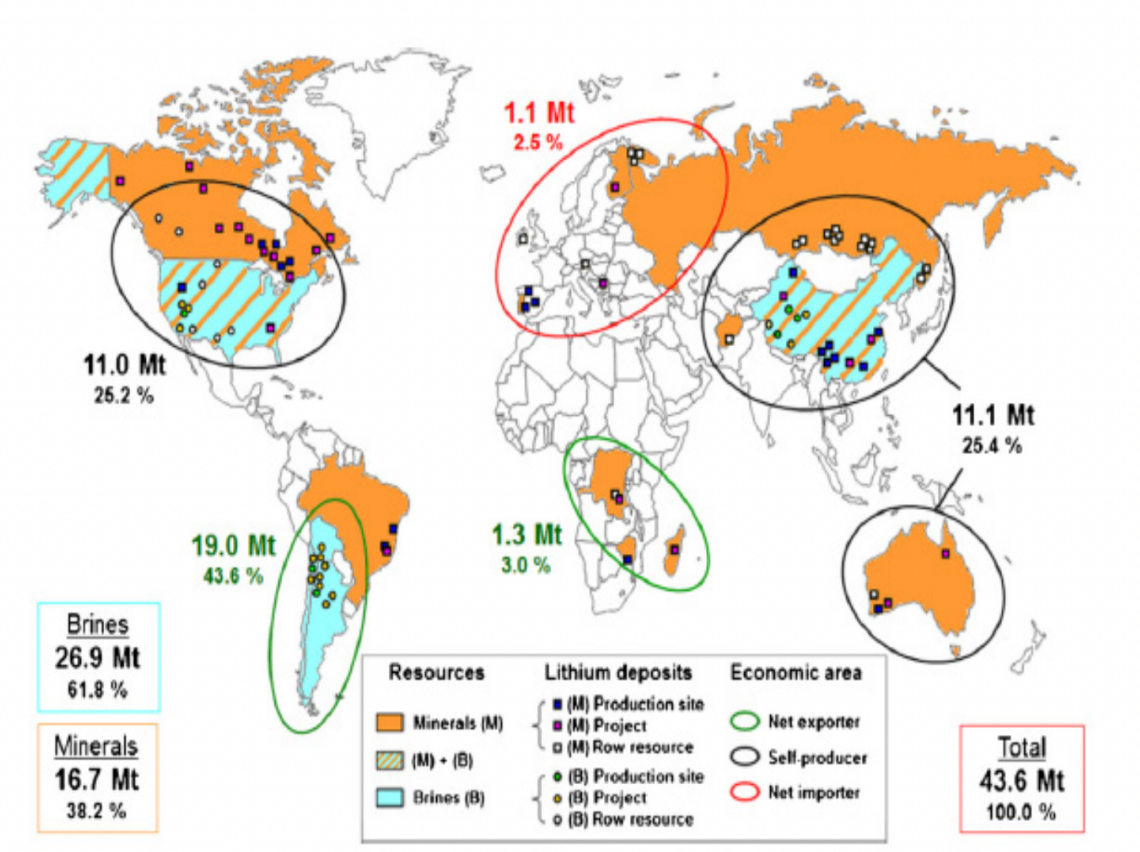
supply shocks in global markets, due to the supply chain being dominated by China. In a complex intersection of global supply chain shifts— such as COVID-19 and trade wars with China— US and EU officials looked towards bringing lithium production and extraction behind borders. A series of legislative and regulatory decisions[64] positioned the lithium battery supply chain as an issue of geo-economic importance for national security and the green energy transition.[65] The US, E.U., and Canada have geopolitically realigned to secure supply chains of key transition metals, highlighting lithium as a geographically abundant resource that could be mined within borders.[66] While other transition minerals like uranium, copper and nickel are found and mined in these regions, lithium has seen vast investment in new mining projects and prospecting. Due to the number of deposits across six continents and relative abundance, (when compared to other transition minerals like cobalt, found primarily in the Democratic Republic of Congo) firms, governments, and stakeholders have greater agency to make decisions about where lithium extraction and processing occurs. The lithium industry provides a rich case to compare and evaluate how and why the locale of extraction is of paramount importance. It also is a case in which policymakers, governments and corporations can look to meet demand while paying specific attention to *where* lithium is sourced from.

[64] See: American Mineral Security Act of 2019; "Executive Order on America's Supply Chains;" the Inflation Reduction Act of 2022; European Commission. Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability (2020).

[65] White House, "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth." (Washington, DC, 2021).

[66] European Commission, "Critical Raw Materials Resilience: Charting a Path towards Greater Security and Sustainability" (2020), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0474.

Figure 1.4 — Global distribution of lithium resources (metric tons) as of 2021[67]



Source: Graham, Rupp, Brungard "Lithium in the Green Energy Transition."

[67] Notes: map is differentiated based on what type of deposit (brine, hard rock or both) present. The map is also divided into production sites, prospective project sites, and untapped reserves.

Third, lithium extraction is aligned politically as a more "sustainable" or "green" industry (as compared to other transition minerals). The expansion of lithium extraction and production networks has been coupled with a "greening" agenda, most intensely in wealthier countries, used as a tactic to justify "onshoring."[68] Due to lithium's positionality as a key element for decarbonization, it has been advertised by corporations as a "green extraction" venture, marketed as more environmentally responsible than other mined commodities.[69] However, lithium, due to its reactivity, is only naturally abundant in compound form, and extracting and refining lithium is both a water and energy intensive process regardless of the type of deposit.[70] Additionally, lithium extraction sites are frequently located in regions with a lack of fresh water, and the presence of extractive industry often only worsens such scarcity. The alignment of lithium mining with a "greening" or sustainability agenda presents a "double

[68] "Onshoring" is a term used by authors such as Riofrancos. It is used to describe the process of expanding domestic extraction/production back behind national borders, for a good that was previously imported or "offshored." The next sections elaborate on onshoring.

[69] Daniel Macmillen Voskoboynik and Diego Andreucci, "Greening Extractivism: Environmental Discourses and Resource Governance in the 'Lithium Triangle,'" *Environment and Planning E: Nature and Space* 5, no. 2 (June 1, 2022): 787–809, https://doi.org/10.1177/25148486211006345; Riofrancos, "The Security–Sustainability Nexus"; Blair et al., "The 'Alterlives' of Green Extractivism."

[70] Lithium reserves take various forms. Lithium salts are found in subterranean brines— saline liquid deep underneath salt flats. There are also hard-rock deposits of lithium, more traditionally mined in open-pit mines. An estimated 87% of global reserves are in brine form, and 13% hard rock. Continental brine or "salars," account for the majority of land-based lithium in the world and is considered more economical than production from hard rock ores. It is between 30% and 50% less expensive but comes with environmental drawbacks such as excessive fresh water use requirements, and large land-use requirements as evaporation ponds are required to refine lithium from brine sources.

bind" of the energy transition.[71] Lithium extraction has well-documented negative externalities such as freshwater exploitation[72], ecological destruction[73], excessive energy use[74] and social pushback.

The "green" image associated with lithium directly links mining activity to "sustainability" in corporate reports and government documents. [75] Lithium's direct connection to a sustainability agenda provides important context for the intent of this study, as I investigate how the sustainability of lithium may shift based on the locale of extraction. In the next section, I justify my comparative case selection of two locales of lithium extraction.

Comparative Case Selection

This is a multi-sited study, comparing two cases where lithium extraction occurs. These sites are Argentina (Salar de Olaroz-Cauchari, Jujuy) and the United States (Nevada). I selected these two sites based on several of Van Evera's criteria,[76] including extreme value on the independent variable, data richness, and variation in dependent variable. I discuss this criterion in detail below.

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[71] Jonas Köppel and Morgan Scoville-Simonds, "What Should 'We' Do? Subjects and Scales in the Double-Bind between Energy Transition and Lithium Extraction," *The Extractive Industries and Society* 17 (March 1, 2024): 101376, https://doi.org/10.1016/j.exis.2023.101376.

[72] Bustos-Gallardo, Bridge, and Prieto, "Harvesting Lithium."

[73] Datu Buyung Agusdinata et al., "Socio-Environmental Impacts of Lithium Mineral Extraction: Towards a Research Agenda," *Environmental Research Letters* 13, no. 12 (November 2018): 123001, https://doi.org/10.1088/1748-9326/aae9b1; Sebastian Luckeneder et al., "Surge in Global Metal Mining Threatens Vulnerable Ecosystems," *Global Environmental Change* 69 (July 1, 2021): 102303, https://doi.org/10.1016/j.gloenvcha.2021.102303.

[74] Marie Forget and Vincent Bos, "Harvesting Lithium and Sun in the Andes: Exploring Energy Justice and the New Materialities of Energy Transitions," *Energy Research & Social Science* 87 (May 1, 2022): 102477, https://doi.org/10.1016/j.erss.2021.102477.

[75] Voskoboynik and Andreucci, "Greening Extractivism."

[76] Van Evera, *Guide to Methods for Students of Political Science*.

Extreme value on the independent variable, locale of extraction (referring to the geographic relationship between where raw resources are extracted, produced, and ultimately consumed) is exhibited in this comparison. Lithium extracted from Jujuy province is exported to global markets, processed into batteries far away from extraction sites, by producers like China. In contrast, Nevada lithium looks to supply for domestic markets, therefore the processing and end-use consumption of the good is contained within borders. Therefore, these cases provide an excellent opportunity to compare how this extreme value independent variable[77] may influence the dynamics of extraction and sustainability.

Both sites have been producing lithium for the last ten years, during the timeframe of this study, and continued operations to the present day. Additionally, Jujuy province is the site of two different lithium mining ventures, one beginning operations in 2014, and another coming online in recent years, therefore there is an abundance of geological reports, satellite images, and data on this region. Similarly for Nevada, existing lithium production in the one site producing, as well as new prospecting interests across the state have provided a vast amount of data on the operations and viability of extraction in this locale. Therefore, both cases fulfill Van Evera's criteria of data richness.

Finally, these two sites have variation in the emergence of their extraction dynamics and potential sustainability, fulfilling Van Evera's criteria of variation in the dependent variable. In Jujuy, mining activity in Jujuy is spurred by high levels of foreign investment (including China and US). Jujuy province also has a well-documented relationship with mining activity that predates lithium extraction,

[77] Van Evera.

and is home to other extractive industries such as zinc, silver, copper and gold.[78] Jujuy province has seen an uprising of social protest against the expanding lithium industry in some parts, as the mining threatens fresh water access and threatens the land rights of indigenous people, and relative acceptance in others. Argentina's legacy of colonialism, an export-oriented resource economy, a history of boom-and-bust resource cycles and high inflation are conclusive with the criteria for theories of extractivism to unfold.

Nevada, in contrast, is a site of lithium extraction in a country with a stable market economy, relatively under-developed, but rapidly expanding mining sector. In Clayton Valley, lithium production has higher labor costs, and investment from domestic firms that provide for domestic markets. In this region, fewer firms have been given water rights to operate due to limited fresh water as the most arid state in the nation.[79] Development strategies have been made to process lithium into batteries all within the state of Nevada. Additionally, new water-conserving technologies are under-development in Nevada, such as direct-lithium extraction in response to local concern and ecological limitations on water use.[80]

This case selection fulfills several of Van Evera's criteria, including data richness, extreme value on the independent variable (proximity of extraction-consumption), and variation of the dependent variable (extraction dynamics) between cases. It also may provide a criterion in which extractivist theory

[78]Dorn and Dorn, "Changing Territorialities in the Argentine Andes"; Dorn and Dorn; Anlauf, "Greening the Imperial Mode of Living? Socio- Ecological (in)Justice, Electromobility, and Lithium Mining in Argentina."

[79] By Daniel Rothberg, "Lithium Companies Fight Over Water in the Arid Great Basin," *Inside Climate News* (blog), April 8, 2024, https://insideclimatenews.org/news/08042024/nevada-great-basin-lithium-fight-over-water/.

[80] "New Lithium Mining Method Could Save Ground Water Resources in Nevada," KUNR Public Radio, August 30, 2024, https://www.kunr.org/local-stories/2024-08-30/new-lithium-mining-method-could-save-ground-water-resources-in-nevada.

predicts a difference in dynamics of lithium extraction between Argentina and the United States. This comparative case study empirically investigates these predictions, discovering if dynamics of extraction are similar or different between cases.[81]

Lithium is growing in importance and shifting geopolitics; therefore, these are "revelatory cases"[82] because they provide insight into the under-studied relationship between locale and extraction dynamics. It allows me to compare how different final market destinations (Jujuy exports lithium to global markets vs. Nevada provides for domestic market) impact practices used and the long-term viability, and sustainability of each site. In this case comparison, I investigate how resource disputes, such as energy and water use are addressed in each region, how practices and community engagement differ across contexts, and regulatory and permitting processes unfold.

There are other cases that could be compared to answer my research questions.[83] For example, I could use sites in Chile or Bolivia instead of Argentina, and sites in Canada or Portugal instead of the United States. However, the selected sites in Jujuy, Argentina and Nevada, USA have seen similar expansion of lithium mining activity in the past ten years, are both located in the western hemisphere

[81] Van Evera, *Guide to Methods for Students of Political Science*.

[82] Yin, *Case Study Research*.

[83] For this thesis, China is not selected as a case study or discussed in depth. Despite its extremely important role in the lithium industry as both a site of extraction, production and downstream manufacturing on lithium products, as a case it would not answer the questions posed in the study for a few factors: China provides for both domestic and foreign markets; China both extracts and refines transition minerals; China both exports for global markets, and provides end-use technologies for domestic markets. China does not fit into the binary presented in the core-periphery theory that my study interrogates, nor does the country have accessible data on the lithium industry. However, the findings of this study could have implications for Chinese extraction and production networks, discussed in the final chapter.

and therefore subject to American trade agreements, allowing subsidiaries of the companies such as Lithium Americas and Albemarle to operate in both regions.

Methods and Sources

I used a mixed methods approach to compare these two sites. My methodological data collection and analysis approach combined quantitative analysis of resource intensity metrics with qualitative investigation of governance, policy and permitting processes. I used quantitative metrics for water consumption per ton of lithium carbonate equivalent (LCE) produced. Water use was chosen due to both sites' conflict around water uses and documented overconsumption of freshwater and groundwater attributed to lithium extraction globally. In addition to water metrics, I compared energy consumption and sources used in each case (renewable or not). Energy use is an important determinant of "sustainability" and market viability of lithium production. As new extraction methods emerge, such as direct-lithium-extraction (DLE) that use less water, but more energy, questions of energy availability are extremely context dependent and can influence the long-term sustainability of extraction ventures. Other dynamics of extraction documented include, permitting processes for exploration and expansion of lithium mining (this includes community engagement and ecological impact assessment), water governance structures, legal pathways for contestation of lithium extraction, employment, and development of value-added supply chains (production facilities, battery manufacturing etc.).

My data collection drew from both primary and secondary sources. Primary sources included corporate Environmental Impact Assessments (EIAs), regulatory filings with the Nevada Division of Environmental Protection and Argentine Ministry of Mining, and corporate sustainability reports. I

also utilized USGS Mineral Reports, the International Energy Agency reports and company survey data. These documents provided standardized data on resource utilization and environmental impacts. Additionally, key informant interviews (n=18), with government officials, environmental scientists, academic experts, and community non-profits and leaders of indigenous groups offered insights into operational decisions and local impacts. The majority of these key informant interviewees were based in the Nevada case, with only two key-informant interviews related to the Jujuy case.

Secondary sources encompass academic literature on lithium extraction efficiency, water and energy governance studies, and analyses of global production networks. These sources provided historical context and theoretical frameworks for understanding how different extraction methods emerge and develop in response to local conditions. The research particularly emphasizes historical water and land use patterns, energy infrastructure development, and transportation networks as key factors shaping extraction practices. Additionally, for the Jujuy case I analyzed ethnographic work conducted in the region and analyzed interview transcripts provided by a scholar and key informant who previously conducted field work in Jujuy related to lithium.

My analysis process proceeded in three stages. First, I collected and standardized quantitative metrics for both Nevada and Jujuy, including water usage per ton of lithium carbonate equivalent (LCE), annual brine consumption, energy requirements, and employment statistics. This enabled direct comparison of environmental and economic impacts across regions with similar arid conditions but different governance structures. Second, I conducted qualitative analysis by examining region-specific factors including water governance frameworks, political decision-making processes, and historical

context. This involved coding data from corporate responsibility reports, government regulations, and key informant interviews to better understand how the difference in locale influences extraction practices. Finally, I synthesized these findings through a political ecology framework to demonstrate how power relations and governance decisions—not just technical considerations—shape sustainability outcomes in lithium extraction.

To ensure reliability and address potential biases, I employed systematic data triangulation. Triangulation uses multiple independent sources, with the goal of convergence.[84] This method strengthens the validity of the case study. Company-reported metrics were cross-referenced with government monitoring data, independent academic studies, and local environmental impact reports. This approach helps mitigate several methodological challenges, including different reporting standards between the United States and Argentina, potential data gaps, and seasonal variations in production metrics. Where direct measurements are unavailable, the analysis emphasizes relative rather than absolute comparisons to maintain analytical validity.

Time Frame Rationale

This thesis focuses on the period from 2015 to February 2025, with 2015-2020 providing recent historical context and 2020-2025 capturing current trends and near-future projections. This timeframe

[84] Yin, *Case Study Research*.

is chosen because it encompasses a period of significant growth and change in the global lithium market, driven by increasing demand for electric vehicles and renewable energy storage.[85]

For Argentina, this marks a period of social unrest and protest to mining activity, significantly stunting progress for lithium mining companies.[86] Lithium production increased dramatically during this period. The mines in Jujuy expanded several times since 2016, and now it is one of the largest mining areas in the world.

For the United States, this period captures the expansion of existing operations and the development of new projects in Nevada, providing insight into how a region adapts to a new resource boom. It also captures the impact of sweeping "green" legislation like the Inflation Reduction Act and the Mineral Security Act, which increased demand for domestically sourced lithium and heightened concerns about the production networks of lithium-ion batteries.[87] While only one firm currently produces in the region, with mineral prospecting at 60 new sites in 2023, and as of February 2025, two new projects have been permitted and expect to produce lithium within the next five years.[88] As a

[85] Adriana Carvalho, "Argentina Could Be Epicenter of New Stage of Lithium Supply," August 14, 2023, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/081423-argentina-could-be-epicenter-of-new-stage-of-lithium-supply.

[86] Dorn and Dorn, "Changing Territorialities in the Argentine Andes"; Blair et al., "The 'Alterlives' of Green Extractivism."

[87] White House, "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth."

[88] Bill Dentzer, "Nevada's next Boom: Demand Poised to Spur Silver State's Lithium Production," *Las Vegas Review-Journal* (blog), October 3, 2021, https://www.reviewjournal.com/local/local-nevada/nevadas-next-boom-demand-poised-to-spur-silver-states-lithium-production-2451259/.

lithium boom occurs in the region, disputes over water use, local governance and processes are increasingly pertinent.

This time frame allowed me to examine both continuity and change in extractivist dynamics, providing enough historical context to understand the development of current practices while also capturing recent and ongoing changes that may indicate future trends.

Limitations

While this research design offers a robust approach to examining the impact of locale on extractivist dynamics, it does have some limitations. First, different measurement methodologies between sites necessitated careful standardization protocols. I mitigated this by using relative data when available, rather than absolute and ensuring metric conversions. Second, access constraints limited key informant interviews to remote, phone or video calls and my research does not include fieldwork. To mitigate this, I ensured that I spoke with key informants on video call when possible and recorded all interviews. Due to my inability to conduct in-person field work, I accessed comprehensive documentary evidence and remote sensing data. Third, for key informant interviews, while conducted with both Nevada and Argentine sources—a limitation with the Argentine interviews was access and responsiveness of potential interviewees. Therefore, I have more data from the Nevada key-informant interviews. To compensate for this limitation, I accessed interviews conducted by other scholars in Jujuy and analyzed their ethnographic findings. Fourth, the availability and quality of data varied between the two cases, affecting the depth and comparability of my analysis. I triangulated data from multiple sources and explicitly discussed any inconsistencies or gaps in the available information. Sixth, the

lithium industry is changing rapidly, which means some of my findings may become outdated quickly. To address this, I focused on identifying broader patterns and mechanisms rather than specific outcomes. Despite these limitations, this research design provides a strong foundation for examining the complex relationship between locale and extractivist dynamics across multiple scales.

CHAPTER SUMMARY

The following chapters investigate to what extent geographic and local context influences practice of extraction. Chapter two is a literature review of existing scholarship on extractivism, core-periphery models, and a critique of existing scholarship on lithium extraction and the energy transition to demonstrate a gap in the literature which this thesis seeks to address. Chapter three is an empirical chapter that frames the case of Jujuy and the dynamics of extraction that emerge there. Chapter four is another empirical chapter that focuses on the dynamics of extraction that emerge in the Nevada case. Chapter five is an analysis of these empirical findings that connects how differences in extraction dynamics across locations connect to sustainability outcomes. Chapter six, the concluding chapter, draws implications for the findings of this thesis to theory and practice, and proposes areas for future research.

CHAPTER TWO: THE DEBATE ON EXTRACTION AND SUSTAINABILITY

> To critique contemporary narratives of commodity supply is also to call for a critical socio-spatial accounting of the capital and resource flows that materially make possible the experience of post-industrialism. This is a process of writing the 'invisible' geographies of capital and nature that remain materially central, yet discursively peripheral, to contemporary experience.
>
> — Gavin Bridge, "Resource Triumphalism: Postindustrial Narratives of Primary Commodity Production"[1]

Introduction

Three bodies of literature inform this study of how locale impacts dynamics of lithium extraction and sustainability. They are: core-periphery theory and extractivism, literature on sustainable extraction, and the existing literature on lithium extraction. First, I examine theories of extractivism, particularly focusing on core-periphery models and unequal exchange. A review of this literature demonstrates a debate emerging about the assumption of a rigid Global North-South divide, and an opposition between extraction and sustainability that may not fully capture how contemporary extraction dynamics unfold in new spatial contexts. These limitations underscore the need for this study. Second, I examine environmental dimensions of extraction—including ecological unequal exchange, the efficacy of green extractivism—and the debate on how sustainability is legitimized and leveraged across geographic contexts. Third, I critique existing literature on lithium extraction, addressing gaps in current understandings. Together, these bodies of literature establish the intellectual foundation for this study and identify the theoretical gaps in scholarship that my argument addresses.

[1] Gavin Bridge, "Resource Triumphalism: Postindustrial Narratives of Primary Commodity Production," Environment and Planning A: Economy and Space 33, no. 12 (December 2001): 2149–73, https://doi.org/10.1068/a33190.

Historical Extractivism and the "Core-Periphery" Model

To study the impact of locales on raw material extraction dynamics and sustainability, a review of existing extractivist theory and underlying core-periphery models is required. Core-periphery theory was developed in the 1960s by an economist, Raul Prebisch [2] in his study of Latin-America's underdevelopment. Prebisch argued that Latin America's underdevelopment could be attributed to a power and trade imbalance in which Latin America became "peripheral" to core countries like the United States. This means that Latin American countries export unrefined or raw materials, allowing the upstream processing, technological advancements and surplus to become consolidated in wealthier "core" countries.

Economist John Friedmann, three years later, added to the literature on core-periphery theory, through his case study of regional development policy in Venezuela.[3] Both economists found that the periphery becomes "less-developed" without access to finished goods, industrial development, or the technologies of manufacturing, but instead becomes burdened with the environmental, social and economic repercussions of raw material export. Within these core–periphery dynamics, peripheral regions were forced to specialize in the extraction and export of raw materials, while the core developed industry and produced manufactured goods.[4] Former Brazilian President, Fernando Cardoso, wrote on

[2] Raul Prebisch, "The Economic Development of Latin America and Its Principal Problems.," 1962.

[3] John Friedmann, *Region Development Policy: A Case Study of Venezuela* (MIT Press, 1966).

[4] Albert Acosta, "Extractivism and and Neo Extractivism: Two Sides of the Same Curse," in *Beyond Development: Alternative Visions from Latin America* (Transnational Institute, 2011), 61–86.

Latin America in the late 1970s, developing "dependency theory,"[5] in which he argued that this region failed to reach higher stages of economic development because of dependence on raw material export to wealthier countries, without the ability to develop domestic industrial growth or improve laborers skill levels. This falls into a broad category of uneven development, a multi-scalar concept in which some areas develop at the expense of others.[6]

While this theory emerged through a study of Latin American underdevelopment in the 1960-70s, it was further specified to the case of raw material extraction in literature on "extractivism." In Steven Bunker's case study of extractive export economies in the Brazilian Amazon (from colonialism to the 1970s)[7] he traced the origins of modern-day unequal exchange to relationships that originated during Portuguese colonization of Brazil. Bunker argues that the persisting dynamics of unequal exchange operate through the same core-periphery model Friedmann and Prebisch developed, as Portugal exported the raw timber from colonial Brazil. The term "extractivism" was then coined, derived from the Portuguese concept of "extractivísmo," referring to for-profit deforestation of the Brazilian Amazon. The term further proliferated in the 1970s to describe developments in the mining, oil, and

[5] Fernando Henrique Cardoso, "The Consumption of Dependency Theory in the United States," *Latin American Research Review* 12, no. 3 (1977): 7–24, https://doi.org/10.1017/S0023879100030430.

[6] Werner, Marion, and Jennifer Bair. "Global Value Chains and Uneven Development: A Disarticulations Perspective." *Chapters*, 2019, 183–98. Smith, N. Uneven Development: Nature, Culture, and the Production of Space. Oxford: Blackwell, 1984.

[7] Stephen G. Bunker, "Modes of Extraction, Unequal Exchange, and the Progressive Underdevelopment of an Extreme Periphery: The Brazilian Amazon, 1600-1980," *American Journal of Sociology* 89, no. 5 (March 1984): 1017–64, https://doi.org/10.1086/227983.

timber export sectors across Latin America including countries such as Argentina, Brazil, Venezuela, and Chile.[8]

Extractivism, in contemporary contexts, is defined by scholar Albert Acosta as "huge volumes of natural resources, which are not at all or only very partially processed and are mainly for export according to the demand of central countries."[9] Central countries, in this case, are the "core," explained above. This definition of extractivism places the site of extraction in the "periphery," where material exploitation occurs dislocated from the site of production and consumption. Scholars have expanded use of the term extractivism beyond the industries and geographies of Latin America, referring to systems of globalized extraction and production networks that exploit resource rich regions to provide for global consumption. While the terms "core" and "periphery" are useful for understanding this theory on multiple scales (given that peripheries can occur both within national contexts e.g. rural/urban, and internationally), recent literature has expanded this core-periphery distinction to global levels. The terms global North and global South[10] are used to describe a separation between more

[8] Eduardo Gudynas, "Extractivisms: Tendencies and Consequences," in *Reframing Latin American Development*, ed. Ronaldo Munck and Raúl Delgado Wise, 2018.

[9] Alberto Acosta, "Después Del Saqueo: Caminos Hacia El Posextractivismo.," in *Perspectivas, Análisis y Comentarios Políticos América Latina*, No. 1 (Heinrich Böll Stiftung, 2015), 12, https://mx.boell.org/sites/default/files/perspectivas_1_version_online.pdf.

[10] The term "global South" was coined by an American writer, Carl Ogelsby, writing on the war in Vietnam, who distinguished a geographic power relation in which the North held "intolerable" power of domination over the "global South. It became solidified by the 1980 Brandt report, in which the "Brandt line" was drawn to divide countries with relatively high GDP-per-capita from poorer ones. These terms "global North" and "global South" are used across the literature in addition to "developed" and "developing nations." There is controversy about the applicability and verbiage of these terms, but for this purpose, I use the terms "global North" and "global South" to illustrate the proposed dichotomy in the literature and academic debates.

developed and less developed regions of the world, respectively. "Global North," in this case, does not serve as a geographic descriptor, but refers to the relative power and wealth of countries compared to other parts of the world; the "global North" typically includes North America, Europe, Australia. The "global South," for these purposes, refers to "developing" countries, often categorized by dependency on raw material exports and low GDP-per-capita.

Given these distinctions, authors, such as Svampa,[11] have proposed expanded definitions of extractivism as political-economic-narrative consensus that describes the onset of a new economic and political order. This new order builds upon core-periphery theory, led by increasing demand for raw materials and consumer goods by economies in the global North.[12] This global order positions extractivism as a way of thinking, one that is "towards the goal of maximizing benefit through extraction, which brings in its wake violence and destruction."[13] Extractivist literature has expanded applications of the term beyond resource extraction, used by authors to describe processes of exploitative accumulation,

[11] Maristella Svampa, "Resource Extractivism and Alternatives: Latin American Perspectives on Development," *Journal Für Entwicklungspolitik* 28, no. 3 (2012): 43–73, https://doi.org/10.20446/JEP-2414-3197-28-3-43.

[12] Thomas Wiedmann and Manfred Lenzen, "Environmental and Social Footprints of International Trade," *Nature Geoscience* 11, no. 5 (May 2018): 314–21, https://doi.org/10.1038/s41561-018-0113-9.

[13] Francesco Durante, Markus Kröger, and William LaFleur, "Extraction and Extractivisms: Definitions and Concepts," in *Our Extractive Age: Expressions of Violence and Resistance*, 1st ed., n.d.

resting on unequal power dynamics, encompassing digital,[14] financial,[15] and agrarian[16] extractivism. However, for the purpose of this thesis, expanding notions of extractivism beyond the exploitation of raw materials, results in a loss of the term's explanatory power.[17]

Extractivist theory is based on dynamics of extraction that persist in locales providing commodities for global markets,[18] with case studies primarily originating in Latin America.[19] In these cases, national economies often become dependent on exporting extractive goods, and large investments from state-owned enterprises in extraction. Extractivist development policy encourages foreign investment by limiting environmental regulation and privatizing access to water.[20] These policies

[14] Christopher Chagnon et al., "From Extractivism to Global Extractivism: The Evolution of an Organizing Concept," *Journal of Peasant Studies* 49 (May 9, 2022), https://doi.org/10.1080/03066150.2022.2069015.

[15] Verónica Gago and Sandro Mezzadra, "A Critique of the Extractive Operations of Capital: Toward an Expanded Concept of Extractivism," *Rethinking Marxism* 29, no. 4 (October 2, 2017): 574–91, https://doi.org/10.1080/08935696.2017.1417087.

[16] Ben M. McKay and Henry Veltmeyer, "Industrial Agriculture and Agrarian Extractivism," in *Handbook of Critical Agrarian Studies*, ed. A. H. Akram-Lodhi et al. (Edward Elgar Publishing, 2021), https://doi.org/10.4337/9781788972468.00065.

[17] Gudynas, "Extractivisms: Tendencies and Consequences."

[18] Durante, Kröger, and LaFleur, "Extraction and Extractivisms: Definitions and Concepts."

[19] Bunker, "Modes of Extraction, Unequal Exchange, and the Progressive Underdevelopment of an Extreme Periphery"; Facundo Martín, "Reimagining Extractivism: Insights from Spatial Theory," in *Contested Extractivism, Society and the State*, ed. Bettina Engels and Kristina Dietz (London: Palgrave Macmillan UK, 2017), 21–44, https://doi.org/10.1057/978-1-137-58811-1_2; Kristina Dietz and Bettina Engels, "Contested Extractivism, Society and the State: An Introduction," in *Contested Extractivism, Society and the State*, ed. Bettina Engels and Kristina Dietz (London: Palgrave Macmillan UK, 2017), 1–19, https://doi.org/10.1057/978-1-137-58811-1_1; Acosta, "Después Del Saqueo: Caminos Hacia El Posextractivismo."

[20] Tom Perreault, "Dispossession by Accumulation? Mining, Water and the Nature of Enclosure on the Bolivian Altiplano: Antipode," *Antipode* 45, no. 5 (November 2013): 1050–69, https://doi.org/10.1111/anti.12005; Thomas Perreault, "From the Guerra Del Agua to the Guerra Del Gas: Resource Governance, Neoliberalism and Popular Protest in Bolivia: Antipode," *Antipode* 38, no. 1 (January 2006): 150–72, https://doi.org/10.1111/j.0066-4812.2006.00569.x.

perpetuate local violence, human rights abuses and exploitation to supply raw materials to global markets and remain competitive amidst price volatile commodity markets.[21] This dynamic of extractivism is defined by authors Dunlap and Jakobsen as a violent process, which they term extractivism a "capitalist world-eater."[22] "Neo-extractivist" paradigms have emerged along with new material extraction frontiers, citing extractivist policy as a pathway towards greater equity and as a social imperative for resource-dependent economies.

However, Acosta argues that "neo-extractivism, " while a prominent paradigm of development for many Latin American countries, fails to address the fundamental ills of extractivism. He argues that patterns of social and environmental inequality persist because neo-extractivism functions within the wake of extractivism, and the issue of externally driven demand has not been addressed as neo-extractivism takes shape in export-led national economies. Extractivist theory has clear applicability for how dynamics of extraction operate in global South countries, with legacies of colonial exploitation, that primarily export raw materials to global markets.

There are limitations to the explanatory power of extractivist theory, especially as geopolitical realignments to secure transition minerals result in expanding extractive activity into new locales, outside of the global South.[23] Author, Facundo Martín, critiques the version of extractivism presented

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[21] Eduardo Gudynas, "Climate Change and Capitalism's Ecological Fix in Latin America," in *Critical Currents*, 6, 2009, 36–41.

[22] Alexander Dunlap and Jostein Jakobsen, *The Violent Technologies of Extraction: Political Ecology, Critical Agrarian Studies and the Capitalist Worldeater* (Cham: Springer International Publishing, 2020), https://doi.org/10.1007/978-3-030-26852-7.

[23] Sophia Kalantzakos, "The Race for Critical Minerals in an Era of Geopolitical Realignments," *The International Spectator* 55, no. 3 (July 2, 2020): 1–16, https://doi.org/10.1080/03932729.2020.1786926; Chi-Wei Su et al., "Does

by the primary extractivist authors, Acosta and Gudynas. Martín incorporates spatial theory into extractivism, asserting that both extractive zones and locales of consumption play central roles in creating narratives about progress and development. Martín claims that extractive activity occurs in "uncertain zones that challenge our sense of security and perception of space as something ordered and fixed,"[24] therefore, extractive spaces can be understood as "states of exception"[25] in which processes of legitimation or opposition can unfold. As such, Martín calls for a spatial consideration of extractivism, beyond the simplified picture of traditional extractivist theory, because operations of power produce territories in a way that "destabilizes binary divisions."[26] Martín concludes by suggesting that a locale specific, multi-sited investigation of extractive spaces could provide insight into how extraction unfolds beyond the binary divisions assumed by extractivist theory. Chagnon et al. echoes this call for expanding the conception of extractivism, arguing that extractive frontiers are emerging "across increasingly diverse geographies and denote a more nuanced understanding of global colonialities, beyond the traditional core-periphery dynamics."[27]

Acosta argues that it is the over consumption of "central countries," that requires the "periphery" to adapt to meet external for raw commodities resulting in exploitation and extraction beyond the

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Renewable Energy Redefine Geopolitical Risks?," *Energy Policy* 158 (November 1, 2021): 112566, https://doi.org/10.1016/j.enpol.2021.112566.

[24] Hetherington qtd. in Martín, "Reimagining Extractivism."

[25] Giorgio Agamben, "Estado de Excepción," in *Homo Sacer II, 1.*, ed. Adriana Hidalgo (Valencia: Pre-Textos., 2003).

[26] Martín, "Reimagining Extractivism," 36.

[27] Chagnon et al., "From Extractivism to Global Extractivism."

ecological boundaries of extraction locales.[28] Amidst global sustainability concerns, authors have argued that scholars argue that this practice of extractivism is "diametrically opposed to the concept and practices of sustainability."[29] As such, in this study of dynamics of extraction and the possibility of sustainably extracting transition minerals, extractivist dynamics present a dilemma for the viability of a "green" energy transition. However, as the applicability of traditional extractivist theory is challenged by new extractive frontiers emerging in the global North, and sustainability and extraction become politically aligned in the energy transition, there is a need to uncover if and why location of extraction matters. The scholarship on extractivism infers that unsustainable dynamics persist when materials flow from a periphery to the core, yet further consideration is required as extractive frontiers emerge within "core" countries.

Navigating Sustainability in the Spatial and Material Requirements of the Energy Transition

Sacrifice Zones: The Spatial Importance of the Energy Transition

This thesis focuses primarily on the question of where these material inputs (transition minerals) are sourced from, building upon growing scholarship on the energy transition in the field of political geography that evaluates how new geographies both shape and are shaped by the energy transition.[30] Bridge and Gailing coined the term "new energy spaces" to describe the process of "novel combinations

[28] Christian Dorninger et al., "Global Patterns of Ecologically Unequal Exchange: Implications for Sustainability in the 21st Century," *Ecological Economics* 179 (January 2021): 106824, https://doi.org/10.1016/j.ecolecon.2020.106824.

[29] Chagnon et al., "From Extractivism to Global Extractivism."

[30] Teis Hansen and Lars Coenen, "The Geography of Sustainability Transitions: Review, Synthesis and Reflections on an Emergent Research Field," *Environmental Innovation and Societal Transitions* 17 (December 1, 2015): 92–109, https://doi.org/10.1016/j.eist.2014.11.001.

of energy systems and social relations across space"[31] as the energy transition takes place. Bridge and Gailing assert that existing patterns of uneven development inform how these new industries, technologies and demand for materials manifests across space, potentially deepening economic, social and environmental divides. To achieve a "just" and therefore sustainable energy transition, scholarship looks to address inequality and uneven development rather than allow historical dynamics of unequal exchange to persist. [32]

Scholars argue that new regions, communities and ecologies have and will continue to become "sacrifice zones" amidst the energy transition.[33] The term "sacrifice zones" was first coined during the Cold War, then repurposed by Lerner[34] to refer to low-income areas in the US that were sacrificed to industrial toxic chemical pollution. The term "green sacrifice zones" defines geographic frontiers that are "sacrificed" to sustain the green energy transition, incurring the social and environmental costs such

[31] Gavin Bridge and Ludger Gailing, "New Energy Spaces: Towards a Geographical Political Economy of Energy Transition," *Environment and Planning A: Economy and Space*, July 5, 2020, https://doi.org/10.1177/0308518X20939570.

[32] Will Steffen and Mark Stafford Smith, "Planetary Boundaries, Equity and Global Sustainability: Why Wealthy Countries Could Benefit from More Equity," *Current Opinion in Environmental Sustainability*, Open issue, 5, no. 3 (September 1, 2013): 403–8, https://doi.org/10.1016/j.cosust.2013.04.007; Dorninger et al., "Global Patterns of Ecologically Unequal Exchange."

[33] Melanie Pichler, ed., *Fairness and Justice in Natural Resource Politics*, Routledge Explorations in Environmental Studies (London ; New York: Routledge, Taylor & Francis Group, 2017); Christos Zografos and Paul Robbins, "Green Sacrifice Zones, or Why a Green New Deal Cannot Ignore the Cost Shifts of Just Transitions," *One Earth* 3, no. 5 (November 2020): 543–46, https://doi.org/10.1016/j.oneear.2020.10.012; Ryan Holifield and Mick Day, "A Framework for a Critical Physical Geography of 'Sacrifice Zones': Physical Landscapes and Discursive Spaces of Frac Sand Mining in Western Wisconsin," *Geoforum* 85 (October 1, 2017): 269–79, https://doi.org/10.1016/j.geoforum.2017.08.004.

[34] Steve Lerner, *Sacrifice Zones: The Front Lines of Toxic Chemical Exposure in the United States* (MIT Press, 2012).

as pollution, lack of freshwater and human rights violations.[35] The scholarship on "green sacrifice zones," has primarily focused on case studies of how extractive frontiers operate within existing fabrics of historical extractivism, primarily in post-colonial contexts in the global South. While the vast majority of transition mineral extraction currently occurs in the global South, Zografos and Robbins[36] argue that new sacrifice zones should be strategically located, to ensure a more "just-transition" that addresses the inequalities of global extractivism, discussed above.[37]

New extractive lithium frontiers are emerging outside the global South, with projects underway in regions like the Western US, Canada, and multiple countries in Europe. Lithium is a key transition mineral, and due to its abundance in North America and in certain countries across the E.U., it has been positioned as an opportune resource for "onshoring." Riofrancos[38] argues that onshoring of lithium production to the global North takes place in the context of a "security-sustainability nexus" in which states in the global North are positioning themselves as able to legitimize extraction in a sustainable way. Riofrancos describes the security-sustainability nexus as "an interlocking set of policies and justifications that promote lithium extraction and emphasize the environmental credentials of global

[35] Zografos and Robbins, "Green Sacrifice Zones, or Why a Green New Deal Cannot Ignore the Cost Shifts of Just Transitions."

[36] Zografos and Robbins, "Green Sacrifice Zones, or Why a Green New Deal Cannot Ignore the Cost Shifts of Just Transitions."

[37] Yat Yin Lai and Emrah Karakaya, "Rethinking the Sustainability of Transitions: An Illustrative Case of Burden-Shifting and Sociotechnical Dynamics of Aviation Fuel in Sweden," *Energy Research & Social Science* 113 (July 1, 2024): 103574, https://doi.org/10.1016/j.erss.2024.103574.

[38] Thea Riofrancos, "The Security–Sustainability Nexus: Lithium Onshoring in the Global North," *Global Environmental Politics* 23, no. 1 (2023): 20–41.

North mining."[39] Governments in the global North are taking a set of corporate-friendly industrial policies to promote onshoring (e.g. subsidies, direct financing, fast-tracking projects, supply chain coordination and investment in research and development.) This movement has been justified in two ways. First, concerns over supply security particularly in times of global uncertainty and disrupted supply chains and geopolitical tensions, and the need for domestic supply. And second, through the lens of "green extractivism," where sustainability is emphasized as a central aspect of transition mineral extraction in the global North.

Riofrancos illustrates that this sustainability approach relies upon high environmental standards that are framed as a possible competitive advantage for mining operations in the global North which cannot economically compete with low production costs in the global South. This suggests that in addition to extractivism in the global South, states in the global North are attempting to align logics of green-capitalist crisis management to expand extractive frontiers, exploiting existing frontiers while creating new sites of extraction in the global North.

However, despite the need to address the geographic justice of the energy transition, there is debate on how and if expanding mining in the global North truly addresses concerns of global climate justice. Riofrancos argues that that the onshoring movement "misses the point" of climate justice[40] for

[39] Riofrancos, 22.

[40] Thea Riofrancos, "Shifting Mining From the Global South Misses the Point of Climate Justice," *Foreign Policy* (blog), September 24, 2024, https://foreignpolicy.com/2022/02/07/renewable-energy-transition-critical-minerals-mining-onshoring-lithium-evs-climate-justice/.

several reasons. Most saliently, she argues that we should not assume that the global North has more stringent environmental safeguards, citing that many of the mining laws, looking the US as an example, are outdated. Additionally, she cites that extractive frontiers in Europe are in countries such as Spain and Portugal[41] that have the lowest relative environmental regulation of all EU bodies. Riofrancos also argues that similar patterns of core-periphery dynamics persist within global North territories, where marginalized groups are disproportionately impacted by the expansion of extractive or environmentally toxic industry.

This argument is further corroborated by Gavin Bridge's work[42] in economic and human geography. Bridge challenges the notion that resource peripheries are exclusively a phenomenon occurring in developing countries, illustrating that spatial dynamics of resource extraction create peripheries. He argues that resource-dependent regions in developed countries often exhibit similar characteristics to those in the global South, including, economic volatility due to commodity price fluctuations; political marginalization within national context; environmental degradation and social disruption. He proposes that for extraction sites to develop, governing bodies must presume a

[41] Cristina Chaves et al., "Concerns about Lithium Extraction: A Review and Application for Portugal☆," *The Extractive Industries and Society* 8, no. 3 (September 2021): 100928, https://doi.org/10.1016/j.exis.2021.100928; Luís Silva and Siddharth Sareen, "The Calm before the Storm? The Making of a Lithium Frontier in Transitioning Portugal," *The Extractive Industries and Society* 15 (September 1, 2023): 101308, https://doi.org/10.1016/j.exis.2023.101308.

[42] Gavin Bridge, "Resource Triumphalism: Postindustrial Narratives of Primary Commodity Production," *Environment and Planning A: Economy and Space* 33, no. 12 (December 2001): 2149–73, https://doi.org/10.1068/a33190; Gavin Bridge, "Global Production Networks and the Extractive Sector: Governing Resource-Based Development," *Journal of Economic Geography* 8, no. 3 (May 1, 2008): 389–419, https://doi.org/10.1093/jeg/lbn009; Gavin Bridge, "Material Worlds: Natural Resources, Resource Geography and the Material Economy," *Geography Compass* 3, no. 3 (May 2009): 1217–44, https://doi.org/10.1111/j.1749-8198.2009.00233.x.

"bountiful emptiness" to justify the expansion of extraction. As a result, extractive frontiers locate themselves near marginalized communities, frequently on or near indigenous territories, continuing historical patterns of dispossession.[43]

Amidst this debate, the expansion of new extractive frontiers into territories in the global North allows further empirical evidence to contribute to emerging debates about how a "just" transition can occur. As transition mineral mining attempts to reconcile "sustainability" and with "extraction," framed in opposition to other another,[44] the locale where extraction occurs, may have significant implications for the possibility of sustainable extraction. While the literature presents location of extraction and sacrifice zones as a pressing issue, there is a lack of scholarship examining how to truly achieve a just transition. Through investigating and comparing extraction across locales, both in the global North and South, this study investigates the arguments proposed by Bridge and Riofrancos.

The Efficacy of Sustainability in Extractive Sectors and "Green" Extraction

As demonstrated in the review of extractivist literature, historically, raw material extraction has been the antithesis of sustainability. Oil and gas extraction, for example, are linked in geopolitical and

[43] Al Gedicks, "Transnational Mining Corporations, the Environment, and Indigenous Communities," *The Brown Journal of World Affairs* 22, no. 1 (2015): 129–52; "Argentina: The Scramble for Lithium Threatens the Rights of Indigenous Peoples in Jujuy," International Federation for Human Rights, accessed December 14, 2024, https://www.fidh.org/en/region/americas/argentina/argentina-the-scramble-for-lithium-threatens-the-rights-of-indigenous.

[44] Chagnon et al., "From Extractivism to Global Extractivism."

environmental science discourse as "dirty"[45] due to their role in producing carbon emissions and contribution to raising global temperatures above sustainable levels.[46] Sustainability[47] is a dynamic and often vague concept, defined most obtusely by its three pillars, social, economic and environmental. Despite vast scholarship on sustainability[48] that attempts to create a set of defining characteristics[49] and measurements, there is a lack of concurrence across disciplines and industrial sectors, on how to accurately and holistically account for sustainability in a globalized economy.[50] While ambiguous, the term "sustainability" remains pervasive in recent international agendas,[51] corporate reporting[52] and

[45] Lianne Lefsrud, Heather Graves, and Nelson Phillips, "Dirty Oil or Ethical Oil? Visual Rhetoric in Legitimation Struggles," in *Research in the Sociology of Organizations*, vol. 54, 2017, 101–42, https://doi.org/10.1108/S0733-558X2017000054B004.

[46] Christophe McGlade and Paul Ekins, "The Geographical Distribution of Fossil Fuels Unused When Limiting Global Warming to 2 °C," *Nature* 517, no. 7533 (January 2015): 187–90, https://doi.org/10.1038/nature14016.

[47] Sustainability and sustainable development are used interchangeably throughout this thesis as synonyms, although sometimes a distinction is made, see: Tom Waas et al., "Sustainability Assessment and Indicators: Tools in a Decision-Making Strategy for Sustainable Development," *Sustainability* 6, no. 9 (September 2014): 5512–34, https://doi.org/10.3390/su6095512.

[48] Waas et al.; Ibrahim M. Algunaibet et al., "Powering Sustainable Development within Planetary Boundaries," *Energy & Environmental Science* 12, no. 6 (2019): 1890–1900, https://doi.org/10.1039/C8EE03423K; Jochen Markard, Rob Raven, and Bernhard Truffer, "Sustainability Transitions: An Emerging Field of Research and Its Prospects," *Research Policy* 41, no. 6 (July 2012): 955–67, https://doi.org/10.1016/j.respol.2012.02.013; Jonathan Köhler et al., "An Agenda for Sustainability Transitions Research: State of the Art and Future Directions," *Environmental Innovation and Societal Transitions* 31 (June 2019): 1–32, https://doi.org/10.1016/j.eist.2019.01.004.

[49] Four characteristics or principles that are intrinsic to sustainability and sustainable development were determined by (Waas et. al) in their review of sustainability assessment and indicators. They are: equity (defined as justice/fairness in the way we develop); dynamics (approached with precaution to inherent uncertainty and risk); integration of different sustainability practices; normativity (because sustainability is a social construct and based on collective values).

[50] Anke Schaffartzik, Dominik Wiedenhofer, and Nina Eisenmenger, "Raw Material Equivalents: The Challenges of Accounting for Sustainability in a Globalized World," *Sustainability* 7, no. 5 (May 2015): 5345–70, https://doi.org/10.3390/su7055345.

[51] "THE 17 GOALS | Sustainable Development," accessed December 9, 2024, https://sdgs.un.org/goals.

[52] "Advancing Sustainable Value Creation, 2023 ESG Report," ESG-S (Lithium Americas, 2023).

economic policy.[53] As the energy transition unfolds, scholarship has questioned the validity of a sustainable "green" transition.[54] To decarbonize energy sources, and shift away from fossil fuels, extraction of transition minerals must intensify. Scholars argue that the extraction of transition minerals propose an ethical dilemma[55] or "dark side"[56] of the energy transition in which the very goal of sustainability could be undermined by the negative consequences of extraction.[57]

Scholarship attempts to account for sustainability extractive sectors. Morgan's work[58] established the foundation for modern environmental impact assessment for extractive industries, focused on quantifying environmental aspects of extractive processes. O'Faircheallaigh[59] incorporated

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[53] European Commission, "Critical Raw Materials Resilience: Charting a Path towards Greater Security and Sustainability" (2020), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0474; White House, "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth." (Washington, DC, 2021).

[54] Lai and Karakaya, "Rethinking the Sustainability of Transitions"; Dorninger et al., "Global Patterns of Ecologically Unequal Exchange"; Ebru Susur and Emrah Karakaya, "A Reflexive Perspective for Sustainability Assumptions in Transition Studies," *Environmental Innovation and Societal Transitions* 39 (June 2021): 34–54, https://doi.org/10.1016/j.eist.2021.02.001.

[55] Jonas Köppel and Morgan Scoville-Simonds, "What Should 'We' Do? Subjects and Scales in the Double-Bind between Energy Transition and Lithium Extraction," *The Extractive Industries and Society* 17 (March 1, 2024): 101376, https://doi.org/10.1016/j.exis.2023.101376.

[56] Anabel Marín and Daniel Goya, "Mining—The Dark Side of the Energy Transition," *Environmental Innovation and Societal Transitions* 41 (December 2021): 86–88, https://doi.org/10.1016/j.eist.2021.09.011.

[57] Chaves et al., "Concerns about Lithium Extraction."

[58] R.K Morgan, "Environmental Impact Assessment: The State of the Art.," in *Impact Assessment and Project Appraisal, 30(1)*, 2012, 5–15.

[59] Ciaran O'Faircheallaigh, "Public Participation and Environmental Impact Assessment: Purposes, Implications, and Lessons for Public Policy Making," *Environmental Impact Assessment Review* 30, no. 1 (January 1, 2010): 19–27, https://doi.org/10.1016/j.eiar.2009.05.001.

social impact assessment, arguing that environmental and social impacts are inextricably linked in extractive contexts. Presently, various frameworks exist for sustainability indicators in the mining sector,[60] however these frameworks fail to account for the complexity of production networks of extractive industry and therefore provide inconclusive data on the efficacy of sustainable extraction. Given the need to focus on systemic sustainability, "at the operation itself, and across the product chain and local environment,"[61] Azapagic[62] proposes the integration of technical, economic, environmental and social criteria to fully evaluate sustainability. Recent scholarship has highlighted the challenges of standardization across different measurement approaches.[63] This research demonstrates how various sectors have adapted different methodologies to suit their specific contexts, while also noting the difficulties this creates for cross-sector comparison, and the need to evaluate extractive industries individually, using caution when extrapolating findings to other material extraction. [64]

The terms "sustainable" and "green" have been leveraged by mining corporations, governments and politicians to justify the expansion of transition mineral mining despite ethical and environmental

[60] These frameworks include: Mining, Minerals and Sustainable Development (MMSD); International Council on Mining and Metals (ICMM) sustainability principles; Battelle's sustainable business decision framework. For more, see: B. C. McLellan et al., "Incorporating Sustainable Development in the Design of Mineral Processing Operations – Review and Analysis of Current Approaches," *Journal of Cleaner Production* 17, no. 16 (November 1, 2009): 1414–25, https://doi.org/10.1016/j.jclepro.2009.06.003.

[61] McLellan et al.

[62] A. Azapagic, A. Millington, and A. Collett, "A Methodology for Integrating Sustainability Considerations into Process Design," *Chemical Engineering Research and Design* 84, no. 6 (June 1, 2006): 439–52, https://doi.org/10.1205/cherd05007.

[63] Waas et al., "Sustainability Assessment and Indicators."

[64] Bridge, "Global Production Networks and the Extractive Sector."

concerns about the impacts on local communities. As such, the case study method has been employed to investigate case-specific implementation of greening agendas in mining sectors. Authors Voskoboynik and Andrelucci[65] argue that a new wave of "green extractivism" has developed to mitigate global concern about the sustainability of transition mineral mining and obscure the negative local aspects of mining activity. In a case study of the lithium triangle in South America, Voskoboynik and Andrelucci find that a "green extraction" rhetoric is associated with lithium industries in the area. To validate and legitimize the expansion of lithium mining, states and firms in the Lithium Triangle adopt "green" rhetoric. This "green extractivism" paradigm appears in case studies of lithium extraction across South America, categorized by associating of lithium extraction with modern development,[66] ideologies of resource nationalism,[67] and ultimately, framing lithium as a type of "benign" extraction.

Anlauf[68] and Pichler[69] argue that this "green" rhetoric has not been met by shifts in patterns of production and consumption to improve sustainability or reduce the harmful impacts of lithium

[65] Daniel Macmillen Voskoboynik and Diego Andreucci, "Greening Extractivism: Environmental Discourses and Resource Governance in the 'Lithium Triangle,'" *Environment and Planning E: Nature and Space* 5, no. 2 (June 1, 2022): 787–809, https://doi.org/10.1177/25148486211006345.

[66] Javiera Barandiarán, "Lithium and Development Imaginaries in Chile, Argentina and Bolivia," *World Development* 113 (January 1, 2019): 381–91, https://doi.org/10.1016/j.worlddev.2018.09.019; Jennapher Lunde Seefeldt, "Lessons from the Lithium Triangle: Considering Policy Explanations for the Variation in Lithium Industry Development in the 'Lithium Triangle' Countries of Chile, Argentina, and Bolivia," *Politics & Policy* 48, no. 4 (2020): 727–65, https://doi.org/10.1111/polp.12365.

[67] Martín Obaya, "The Evolution of Resource Nationalism: The Case of Bolivian Lithium," *The Extractive Industries and Society* 8, no. 3 (September 1, 2021): 100932, https://doi.org/10.1016/j.exis.2021.100932.

[68] Axel Anlauf, "Greening the Imperial Mode of Living? Socio- Ecological (in)Justice, Electromobility, and Lithium Mining in Argentina," in *Fairness and Justice in Natural Resource Politics*, ed. Melanie Pichler, Routledge Explorations in Environmental Studies (London ; New York: Routledge, Taylor & Francis Group, 2017), 164–80.

[69] Pichler, *Fairness and Justice in Natural Resource Politics*.

extraction. Their argument is backed by findings from a case-study of lithium mining in the Jujuy province in Argentina, where local communities were largely ignored in the regional decision-making process, perpetuating peripheral dynamics essential to extractivism. Environmental degradation and social inequalities at the local level are overlooked when it comes to green technologies, because of the commodity's end use towards a global "green" economy and decarbonization. These green technologies spatially and temporally "externalize" their "socio-ecological costs and constitute a continuation of the global North's imperial mode of living."[70]

This argument uses Brand and Wissen's[71] "imperial mode of living," defined as "exclusive access to resources, guaranteed by contract or through open violence, and the externalization of the socio-ecological costs that using these resources entails." "Imperial" in this definition refers to over-consumptive ways of living in the global North, made possible by exploitation in the global South. In this debate, Anlauf builds upon extractivist theory and core-periphery models, finding that "green" agendas are merely a tactic used to obscure and justify persisting exploitation of communities and landscapes in the global South. Both studies on "green" lithium extraction situate themselves in the

[70] Anlauf, "Greening the Imperial Mode of Living? Socio- Ecological (in)Justice, Electromobility, and Lithium Mining in Argentina."

[71] Ulrich Brand and Markus Wissen, "Crisis and Continuity of Capitalist Society-Nature Relationships: The Imperial Mode of Living and the Limits to Environmental Governance," *Review of International Political Economy* 20, no. 4 (August 1, 2013): 687–711, https://doi.org/10.1080/09692290.2012.691077.

global South, in regions with historical extractivist dynamics. As such, these findings are coherent with claims that extractivism or neo-extractivism are in opposition to sustainable development. [72]

However, sustainability reporting in extractive industries lacks efficacy around the world, and not just in regions with histories of extractivism. While emerging legislature in EU explicitly highlights[73] the prioritization of sustainable sourced transition mineral value chains, the sustainable reporting structures often fail to provide results. This is due to the top-down approach, relying on a concept of "corporate sustainability," and "sustainability management" to determine whether minerals are sustainably sourced. Corporate sustainability includes widely used practices such as environmental, social, governance (ESG) reports that are often utilized to highlight corporations' use of "best practices,"[74] allowing corporations to receive the economic benefit of being "sustainably sourced." Author Ponte[75] argues that sustainability management has emerged as a new dimension of capitalism, where firms can accumulate "green capital" from adding in sustainability management practices in global value chains. However, scholars Böhling et al. find that "sustainable reporting" in the mining sector is relatively symbolic and lacks practical implementation.[76] Through a case study of copper

[72] Acosta, "Extractivism and and Neo Extractivism: Two Sides of the Same Curse"; Chagnon et al., "From Extractivism to Global Extractivism."

[73] European Commission, Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability.

[74] Benjamin K. Sovacool et al., "Sustainable Minerals and Metals for a Low-Carbon Future," *Science* 367, no. 6473 (January 3, 2020): 30–33, https://doi.org/10.1126/science.aaz6003.

[75] Stefano Ponte, "Green Capital Accumulation: Business and Sustainability Management in a World of Global Value Chains," *New Political Economy* 25, no. 1 (January 2, 2020): 72–84, https://doi.org/10.1080/13563467.2019.1581152.

[76] Kathrin Böhling, Diego I. Murguía, and Julieta Godfrid, "Sustainability Reporting in the Mining Sector: Exploring Its Symbolic Nature," *Business & Society* 58, no. 1 (January 2019): 191–225, https://doi.org/10.1177/0007650317703658.

mining in Argentina, they find that the mining sectors conform to external demands and argue that the body of literature on the efficacy and practical implications of sustainable reporting largely ignores the role of local context and stakeholder involvement. Ponte corroborates this in his study of "green capital accumulation," where he argues that sustainability management allows firms to extort profit from global value chains through a mere series of "technological fixes" to meet sustainable management standards rather than improving more impactful aspects of production or extraction.

In Phadke's[77] study of rare earth mining activity in Minnesota, USA, he finds that the term "responsible" mining was employed to pacify social pushback from indigenous communities located near prospective mines and that metrics for responsible mining such as "social license to operate" often rest on an assumption that a lack of opposition from local communities translates to acceptance and support of mining activity. Scholarship on the long-term viability of mining projects concludes that social resistance to mining activity, such as protests and pushback from local communities and indigenous groups, is a huge factor that prevents long-term success of mining projects.[78] The lifespan of a mining operation has sustainability implications, as environmental destruction has already occurred to the landscape.[79] Therefore, to improve the sustainability of mining ventures, community support and engagement can help to improve the longevity and long-term sustainability. This occurs not just

[77] Roopali Phadke, "Green Energy Futures: Responsible Mining on Minnesota's Iron Range," *Energy Research & Social Science* 35 (January 2018): 163–73, https://doi.org/10.1016/j.erss.2017.10.036.

[78] Gedicks, "Transnational Mining Corporations, the Environment, and Indigenous Communities."

[79] Julie Michelle Klinger, *Rare Earth Frontiers: From Terrestrial Subsoils to Lunar Landscapes* (Ithaca: Cornell University Press, 2017).

through lack of social protest, but also through creating relationships between stakeholders at sites of extraction, improving regulation and policy in terms of environmental, economic and social standards.

A review of scholarship on the efficacy of sustainable mining, indicates that across geographic contexts, sustainable extraction presents a problem. However, there are important implications from the literature, such as the role of "greening" agendas to justify extraction practices across geographies. The failure of these sustainability or greening agendas provides a gap that this study seeks to answer, investigating why and if these measures fail differently across geographies, using a bottom-up approach that focuses on the local practice of extraction rather than lofty sustainability incentives.

The Existing Literature on Lithium

This study investigates the dynamics of extraction that emerge around the effort to mine lithium, therefore a review of existing literature on the dynamics of lithium extraction is required. The case selection in Chapter One addresses the reasons for selecting lithium, and previous sections of this literature review references arguments and findings from studies that use lithium extraction sites as case studies.

Research consistently highlights significant environmental concerns around lithium extraction. The majority of global lithium reserves are concentrated in the "Lithium Triangle" spanning Chile, Argentina, and Bolivia.[80] In the Lithium Triangle and across the world, mining operations have been linked to reduced surface water levels, biodiversity loss, elevated daytime temperatures, and worsening

[80] Lunde Seefeldt, "Lessons from the Lithium Triangle."

drought conditions.[81] Several studies examine the complex relationship between lithium mining and indigenous communities in the Lithium Triangle.[82] The literature reveals emerging patterns of resource nationalism and strategic competition, such as exploring how countries like Chile, Bolivia and Argentina have implemented different business models to develop lithium industries.[83]

As extractive frontiers emerge outside of these regions, literature must evaluate how shifting extractive geographies impact dynamics of extraction. This has begun to occur, as authors document challenges that arise with the effort to mine lithium in countries across the global North, including

[81] Datu Buyung Agusdinata et al., "Socio-Environmental Impacts of Lithium Mineral Extraction: Towards a Research Agenda," *Environmental Research Letters* 13, no. 12 (November 2018): 123001, https://doi.org/10.1088/1748-9326/aae9b1; Anlauf, "Greening the Imperial Mode of Living? Socio- Ecological (in)Justice, Electromobility, and Lithium Mining in Argentina"; Bruno Fornillo and Andrea Lampis, "From the Lithium Triangle to the Latin American Quarry: The Shifting Geographies of de-Fossilisation," *The Extractive Industries and Society* 15 (September 1, 2023): 101326, https://doi.org/10.1016/j.exis.2023.101326; James J. A. Blair et al., "The 'Alterlives' of Green Extractivism: Lithium Mining and Exhausted Ecologies in the Atacama Desert," *International Development Policy | Revue Internationale de Politique de Développement*, no. 16 (April 6, 2023), https://doi.org/10.4000/poldev.5284; Beatriz Bustos-Gallardo, Gavin Bridge, and Manuel Prieto, "Harvesting Lithium: Water, Brine and the Industrial Dynamics of Production in the Salar de Atacama," *Geoforum* 119 (February 1, 2021): 177–89, https://doi.org/10.1016/j.geoforum.2021.01.001.

[82] Gedicks, "Transnational Mining Corporations, the Environment, and Indigenous Communities"; Felix Malte Dorn, Hans Gundermann, and Hans Gundermann, "Mining Companies, Indigenous Communities, and the State: The Political Ecology of Lithium in Chile (Salar de Atacama) and Argentina (Salar de Olaroz-Cauchari)," *Journal of Political Ecology* 29, no. 1 (May 28, 2022), https://doi.org/10.2458/jpe.5014; "New Report Finds Nevada's Lithium Mine Permit Violates Indigenous Peoples' Rights," *American Civil Liberties Union* (blog), accessed February 28, 2025, https://www.aclu.org/press-releases/new-report-finds-nevadas-lithium-mine-permit-violates-indigenous-peoples-rights; "Argentina."

[83] Martín Obaya, Andrés López, and Paulo Pascuini, "Curb Your Enthusiasm. Challenges to the Development of Lithium-Based Linkages in Argentina," *Resources Policy* 70 (March 1, 2021): 101912, https://doi.org/10.1016/j.resourpol.2020.101912; Obaya, "The Evolution of Resource Nationalism"; Lunde Seefeldt, "Lessons from the Lithium Triangle."

Portugal,[84] Serbia[85] and Spain.[86] However, these studies focus on the act of legitimizing and expanded extraction and the conflict that arises from mineral prospecting. There is a gap in the literature investigating how dynamics of extraction unfolds in these other contexts.

A bibliometric study by Agusdinata et al.[87] examining lithium extraction research from 1974-2018, reveals a skewed research landscape that prioritizes consumer-centric issues like lithium-ion battery efficiency and costs, viewing these issues as dislocated from producing regions. The authors suggest this research pattern mirrors the priorities and regulations of consuming nations rather than driving new policy directions. Therefore, there is a need to understand how consuming regions adapt to hosting new extractive frontiers and how this differs from solely producing regions. The existing bodies of literature are not able to answer how the locale of extraction (and its proximity to locales of production/consumption) impacts dynamics and sustainability outcomes.

Additionally, while there is a plethora of multi-sited comparative case studies on lithium,[88] the geographic focus of these studies often remains in the global South. A notable exception is Dorn et al's

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[84] Silva and Sareen, "The Calm before the Storm?"; Chaves et al., "Concerns about Lithium Extraction"; Felix Malte Dorn, "Inequalities in Resource-Based Global Production Networks: Resistance to Lithium Mining in Argentina (Jujuy) and Portugal (Região Norte).," *Journal Für Entwicklungspolitik: JEP. 37. 70-91. 10.20446/JEP-2414-3197-37-4-70.*, n.d.

[85] N. Djukanović., "Green Are Fields, Not Mines: The Case of Lithium Mining and Resistance in Serbia" (University of Oxford, 2022).

[86] Carla Noever Castelos, "Mining out of the Crisis? The Role of the State in the Expansion of the Lithium Frontier in Extremadura, Spain," *The Extractive Industries and Society* 15 (September 2023): 101329, https://doi.org/10.1016/j.exis.2023.101329.

[87] Agusdinata et al., "Socio-Environmental Impacts of Lithium Mineral Extraction."

[88] José Carlos Orihuela and Sergio Serrano, "Rules, Institutions and Policy Capacity: A Comparative Analysis of Lithium-Based Development in Argentina, Bolivia and Chile," *Energy Research & Social Science* 118 (December 1, 2024): 103761, https://doi.org/10.1016/j.erss.2024.103761; Victor Ramirez, "Shifting Paradigms in Lithium Extraction: A Comparative Analysis of Technological Efficiency and Economic Viability Behind Mining Techniques: A Case Study of the Lithium Triangle," July 30, 2024, https://dataspace.princeton.edu/handle/88435/dsp01vq27zr798; Felix Malte Dorn and Felix

2021 study of resistance and protest lithium mining activity in Portugal and Argentina.[89] This study found that lithium extraction in both localities resulted in similar inequalities in each location while also producing new intra-societal relations between the global North and South divide. In this study, authors call for further comparative studies that bridge gaps between the global North and South, a gap in the literature, which this study contributes to.

The Gap: Locale of Extraction and Sustainability

This study addresses critical gaps in our understanding of how location shapes extractive dynamics and sustainability outcomes in the context of the energy transition. While existing literature effectively documents how extractivism operates in the global South, particularly in regions with colonial histories, there is limited theoretical understanding of how these dynamics manifest in new extraction frontiers emerging in the global North. As the global energy transition drives demand for lithium and other transition minerals, new extractive frontiers are emerging in closer proximity to sites of consumption and manufacturing. This spatial reconfiguration challenges traditional extractivist theory's assumption of a rigid North-South divide and its emphasis on extraction occurring in peripheral regions far from sites of consumption.

The proximity between sites of extraction and consumption may fundamentally alter the dynamics of extraction and possibilities for sustainability. Traditional extractivist theory suggests that

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Malte Dorn, "Changing Territorialities in the Argentine Andes: Lithium Mining at Salar de Olaroz-Cauchari and Salinas Grandes," *Die ERDE*, 2021, 1–17, https://doi.org/10.12854/erde-2021-515; Dorn, Gundermann, and Gundermann, "Mining Companies, Indigenous Communities, and the State."

[89] Dorn, "Inequalities in Resource-Based Global Production Networks: Resistance to Lithium Mining in Argentina (Jujuy) and Portugal (Região Norte)."

geographic and social distance between extraction and consumption enables exploitation and environmental degradation.[90] However, when extraction occurs closer to sites of consumption, different dynamics may emerge. Local communities in consuming regions may have greater political power to influence extractive practices,[91] while proximity to manufacturing could reduce transportation emissions and enable more integrated supply chains.[92] Alternatively, as Bridge suggests, core-periphery dynamics may simply reproduce at more local scales.[93]

Beyond testing the spatial assumptions of extractivist theory, this study examines how location shapes the efficacy of sustainability initiatives in mining. Current literature demonstrates that sustainability reporting and "green mining" claims often lack practical implementation, particularly in their consideration of local contexts and stakeholder engagement. Given the lack of efficacy in existing sustainable reporting systems, and "green" extraction methods. Authors Schaffartzik et al.[94] look towards accounting for raw material flows between countries, to evaluate sustainability in globalized trade dynamics.[95] They find that this dislocation of raw materials from sites of end consumption creates

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[90] Acosta, "Extractivism and and Neo Extractivism: Two Sides of the Same Curse"; Wiedmann and Lenzen, "Environmental and Social Footprints of International Trade"; Dorninger et al., "Global Patterns of Ecologically Unequal Exchange"; Bunker, "Modes of Extraction, Unequal Exchange, and the Progressive Underdevelopment of an Extreme Periphery"; Brand and Wissen, "Crisis and Continuity of Capitalist Society-Nature Relationships."

[91] Marta Conde and Philippe Le Billon, "Why Do Some Communities Resist Mining Projects While Others Do Not?," *The Extractive Industries and Society* 4, no. 3 (July 2017): 681–97, https://doi.org/10.1016/j.exis.2017.04.009.

[92] Hansen and Coenen, "The Geography of Sustainability Transitions."

[93] Bridge, "Resource Triumphalism."

[94] Schaffartzik, Wiedenhofer, and Eisenmenger, "Raw Material Equivalents."

[95] In this study, they develop a new indicator to measure progress toward global sustainability. The novel process accounts for the upstream, raw material components that go into finished products, and monetary flows. Through their calculations, they can more accurately attribute responsibility for sustainability to the country that consumes the final

a puzzle for accounting for sustainability. As such, this study provides insight into how extraction dynamics differ when this dislocation is mitigated. Within the literature on lithium extraction, this study bridges the geographical divide between global North and South to empirically examine how extraction dynamics unfold across contexts amidst a green energy transition. Bridge states that extractive production networks "remain territorially embedded even while they are reconfigured into new trans-local geographies."[96] Therefore, locale and the territories in which extraction occurs, matter.

Synthesis and Looking Ahead

This literature review has traced three key theoretical foundations for understanding how location shapes lithium extraction dynamics and sustainability outcomes. First, it examined how traditional extractivist theory, built on core-periphery models, may need revision as new extraction frontiers emerge in the global North. Second, it explored debates around sacrifice zones and spatial justice in the energy transition, revealing tensions between local impacts and global sustainability goals. Third, it analyzed existing approaches to sustainable mining, demonstrating the limitations of current frameworks and the need for more nuanced understanding of how local contexts shape outcomes. These gaps underscore the importance of investigating how location shapes both the dynamics of extraction and possibilities for sustainable practices. Such research can inform more effective approaches to

good, rather than the country that produces the raw extracted good. While this process is data intensive and under development, their fundamental idea of placing the sustainability burden on the consumer rather than the producer, by focusing on the upstream, raw material aspects of finished goods is enticing and provides inspiration for the purpose of this thesis.

[96] Bridge, "Global Production Networks and the Extractive Sector."

sustainability in mining while contributing to broader theoretical debates about spatial justice in the energy transition. The next chapter is an empirical chapter on the case of lithium extraction in Jujuy.

CHAPTER THREE: THE CASE OF JUJUY

Places that, to their extractors, somehow don't count and therefore can be poisoned, drained, or otherwise destroyed, for the supposed greater good of economic progress.

—Naomi Klein, *This Changes Everything: Capitalism vs. the Climate* [1]

Introduction

This chapter presents data about lithium extraction in the Jujuy province of Argentina. This chapter combines and analyzes regulatory and community dynamics of mining in Jujuy, Argentina, relying primarily on primary government document analysis and review of secondary sources of ethnographic scholarship conducted in the region. This empirical data seeks to answer the question of what dynamics emerge around the effort to extract lithium in Argentina, providing one of the departure points for the latter comparative case study. Chapter four discusses dynamics in Nevada, USA and chapter five is an analysis and comparison of the two cases, and discussion of findings.

Methodology

This study systematically analyzes existing scholarly literature and documentation. This includes ethnographic studies of mining communities in both regions, policy analyses, historical accounts, and environmental/social impact assessments. The secondary analysis pays particular attention to how other researchers have documented community-mining relationships and regulatory evolution over time.

[1] Naomi Klein, ed., *This Changes Everything: Capitalism vs. the Climate*, First Simon&Schuster export edition (New York, NY: Simon & Schuster, 2014),169 .

Due to the time and geographic limitations of this research, this study relies upon interviews collected by peer-reviewed research conducted in the Jujuy region between 2015-2025. The analysis also incorporates primary documents including policy decisions, regulatory frameworks, and legal precedents that have shaped mining governance in both regions. These documents include environmental impact assessment requirements, community consultation protocols, mining permit processes from Jujuy. I analyze these documents not only for their content but also for how they structure relationships between state, industry, and community actors. The analysis pays particular attention to how policy documents frame the roles and responsibilities of different stakeholders, define consultation requirements, and establish mechanisms for oversight and enforcement. By examining these documents alongside interview data and scholarly analyses, I can better understand how formal governance structures interact with actual practices on the ground. In addition to qualitative data, I combine quantitative metrics such as water-use of firms operating in the region in comparison to water needs of the region.

To enhance analytical validity, findings were triangulated across multiple data sources and types. Where possible, claims about historical events or regulatory processes were verified through multiple scholarly accounts. Contemporary observations from interviews were contextualized within existing literature to identify both consistent patterns and points of departure.

Argentina's Role in Emerging Global Lithium Markets

Argentina emerged as a significant player in the global lithium market when the Salar de Olaroz mine in Jujuy began operations in 2014. This development positioned the country as the world's fourth-

largest lithium producer, behind Australia, Chile, and China, while also establishing it as the second-largest exporter of lithium carbonate.[2] As of 2024, Argentina is estimated to be home to 22 million tons of lithium reserves– a significant percentage out of the estimated world total of 105 million tons.[3] Between 2022 and 2023, Argentina increased lithium production by roughly 146%, increasing total production to 9,600 tons of lithium.[4] The scale of Argentina's lithium mining sector is substantial, with estimates of active projects ranging from 40 to over 60, including various stages from exploration to extraction.[5]

Argentina has welcomed overseas capital in its lithium industry, through a different approach from neighboring countries in the "Lithium Triangle."[6] While Bolivia and Chile have specific rules for

[2] USGS, "Mineral Commodity Summary- Lithium 2022" (US Geological Survery, January 2022).

[3] These numbers are estimations, expected to change based on further exploration and deposit quality, for more see: USGS, "Mineral Commodity Summaries 2024," no. Lithium (2024).

[4] USGS.

[5] For a detailed overview of projects and stages of development see: "Portfolio of Advanced Projects - Lithium" (Secretaría de Minería República Argentina, 2024).

[6] The homogenization of this region into a single 'lithium triangle' disguises different institutional approaches to lithium mining regulation across Argentina, Chile, and Bolivia. While Chile grants permits to private companies by presidential decree and has maintained a duopoly since the 1980s, becoming the world's largest lithium exporter, Bolivia has struggled to advance beyond pilot projects despite emphasizing lithium in its national development plans.

For more information, see: Samar Ahmad, "The Lithium Triangle: Where Chile, Argentina, and Bolivia Meet," Harvard International Review, January 15, 2020, https://hir.harvard.edu/lithium-triangle/; Jennapher Lunde Seefeldt, "Lessons from the Lithium Triangle: Considering Policy Explanations for the Variation in Lithium Industry Development in the 'Lithium Triangle' Countries of Chile, Argentina, and Bolivia," *Politics & Policy* 48, no. 4 (2020): 727–65, https://doi.org/10.1111/polp.12365; Craig A. Johnson et al., "Bringing the State Back in the Lithium Triangle: An Institutional Analysis of Resource Nationalism in Chile, Argentina, and Bolivia," *The Extractive Industries and Society* 20 (December 1, 2024): 101534, https://doi.org/10.1016/j.exis.2024.101534; Victor Ramirez, "Shifting Paradigms in Lithium Extraction: A Comparative Analysis of Technological Efficiency and Economic Viability Behind Mining Techniques: A Case Study of the Lithium Triangle," July 30, 2024, https://dataspace.princeton.edu/handle/88435/dsp01vq27zr798; Javiera Barandiarán, "Lithium and Development

lithium extraction, Argentina manages prospecting and extraction under broader mining laws that embrace free-market principles and foreign investment, dating back to extractivist economic reforms of the 1990s.[7] This framework shapes lithium development in Argentina as distinct, through several key mechanisms. The 1993 Mining Investment Law[8] offers substantial benefits to mining companies, including extensive tax breaks, a guaranteed stable tax environment for three decades, and mining royalties capped at 3%. Argentine Mining Code, enacted in 1887 and reformed in 1997, empowers the private ownership and exploitation of mines.[9] Constitutional changes in 1994, per article 124, meant that control over mining assets shifted to provincial authorities,[10] rather than federal standardization across the country.

Jujuy, Salta, and Catamarca provinces, all contain significant lithium deposits, and independently oversee and regulate lithium operations and foreign investment in their regions without federal oversight. As of 2024, only three mines were producing lithium in Argentina: the Fenix project in Catamarca province, Sales de Jujuy, and Minera Exar, both in Jujuy province.[11] Yet in February 2025,

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Imaginaries in Chile, Argentina and Bolivia," *World Development* 113 (January 1, 2019): 381–91, https://doi.org/10.1016/j.worlddev.2018.09.019.

[7] Federico Nacif, "Litio en Argentina: de insumo crítico a commodity minero. Trayectoria socio-técnica de los yacimientos litíferos de la Puna (1930-2015)," n.d.

[8] "ACTIVIDAD MINERA," Pub. L. No. Ley 24.196 (1993).

[9] Nacif, "Litio en Argentina: de insumo crítico a commodity minero. Trayectoria socio-técnica de los yacimientos litíferos de la Puna (1930-2015)."

[10] "Argentina: Constitución de 1994," accessed February 24, 2025, https://pdba.georgetown.edu/Constitutions/Argentina/argen94_e.html.

[11] More operations are under prospect and development, including new projects in the Olaroz-Cauchari region, including the Minera Exar project operating very close to Sales de Jujuy.

another mine came online to start producing in Salta province under a Chinese-owned company, Ganfeng. This mine is the first of many projects expected to continue to start producing in Argentina in the coming months and years.[12] Focusing on provinces as the locale of extraction is useful, as these governing bodies have much of the control over how mining ventures are permitted, regulated and legitimized.

Extraction in Jujuy– Regulations and Pushback

Each province has different approaches to lithium mining operations. Jujuy province is the most northwestern province in Argentina, bordering Chile to the west and Bolivia to the north (see figure 3.1). It is located within the "Lithium Triangle" and home to some of the world's largest lithium deposits. Jujuy most notably encourages foreign investment and expansion of lithium extraction, taking a more proactive stance in lithium development compared to neighboring lithium-rich provinces, Salta and Catamarca. Under Governor Morales' administration (2015-present) and his predecessors, the province has pursued leadership in lithium value-added production. In 2011, the Barrionuevo administration declared lithium a strategic resource and established JEMSE (Jujuy Energy and Mining State Society) (in decree 7592) to advance mining and renewable energy development.[13] Further decrees by the current Morales administration encouraged public-private partnerships in the region to incentivize mining

[12] "China's Ganfeng Starts Lithium Production at Argentina's Mariana Project | Reuters," accessed February 25, 2025, https://www.reuters.com/markets/commodities/chinas-ganfeng-starts-lithium-production-argentinas-mariana-project-2025-02-12/.

[13] JEMSE maintains an 8.5% stake in private mining ventures within the Jujuy province.

investment.[14] This section focuses on the unique characteristics and brief overview of Jujuy province, a review of existing scholarship on extraction dynamics within the province, and review of the permitting process for lithium projects.

Jujuy is one of Argentina's poorest provinces, and has a significant Indigenous population, including Kolla, Atacameño, Omaguaca, and Guaraní peoples. These communities have faced historical marginalization since Spanish colonization, including land dispossession and labor exploitation.[15] While metal and mineral mining have historical roots in the province, community responses to lithium mining vary significantly across the province. The communities in the department of Susques[16] areas generally cooperate with mining companies actively operating at the Salar de Olaroz-Cauchari and Minera Exar sites. In contrast, the 33 indigenous communities of Salinas Grandes-Guayatayoc[17] (25 in Jujuy, 8 in Salta) actively resist exploration on their territories.

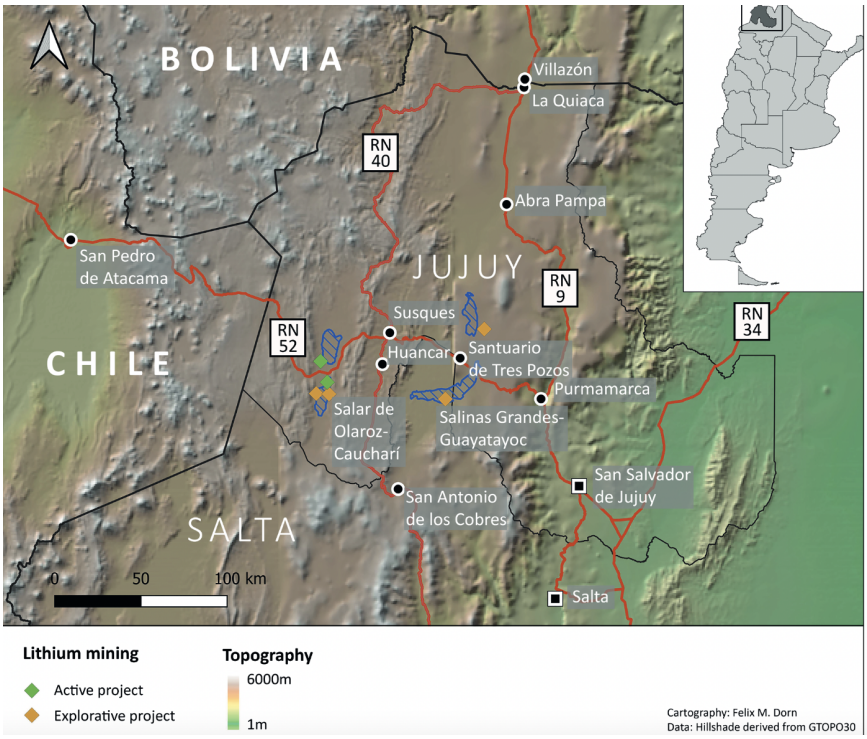
[14] Barandiarán, "Lithium and Development Imaginaries in Chile, Argentina and Bolivia."

[15] This thesis does not cover the time period prior to 2015 in depth, nor does it elaborate upon unique colonial dynamics within this region, for more, see: Sebastián Gómez Lende, "Minería metalífera en la provincia de Jujuy, Argentina: Una historia de acumulación por desposesión (1933-2016)," *Universidad Nacional del Centro de la Provincia de Buenos Aires*, 2016; "Historia – Gobierno de la Provincia de Jujuy," accessed February 25, 2025, https://jujuy.gob.ar/historia/; Barbara Göbel, "La Arquitectura Del Pastoreo: Uso Del Espacio y Sistema de Asentamientos En La Puna de Atacama (Susques)," *Estudios Atacameños*, no. 23 (2002), https://doi.org/10.4067/S0718-10432002002300005; Nacif, "Litio en Argentina: de insumo crítico a commodity minero. Trayectoria socio-técnica de los yacimientos litíferos de la Puna (1930-2015)."

[16] This includes points on figure 3.1: Susques and Huancar. When referring to the "department of Susques" I refer to these community hotspots and the regions surrounding the Olaroz-Cauchari salt flats.

[17]This region includes point in figure 3.1: Santuario de Tres Pozos– this region has benefitted from more tourism and economic prosperity due to its location near to historically busy intersections dating back to the Incan empire, as opposed to the historic marginalization of the regions surrounding Olaroz-Cauchari, for more in depth information comparing these two regions, see: Dorn and Dorn, "Changing Territorialities in the Argentine Andes."

Figure 3.1— Map of Jujuy Province, active and explorative projects



Source: Felix Dorn, 2021[18]

In Jujuy province, mining projects must undergo a unique UGAMP (Unit of Mining Environmental Management) review process. This involves a formal meeting where Aboriginal Authorities, water commission representatives, mines department officials, police, and other stakeholders evaluate presentations by mining companies. Following this meeting, these parties have a 60-day window to raise objections to the mining study or proposed work plan. However, before a UGAMP meeting is scheduled, local community assemblies must provide signed documentation of their approval. According to interviews conducted by scholar Lunde Seefeldt in 2019 this process is

[18] Felix Malte Dorn and Felix Malte Dorn, "Changing Territorialities in the Argentine Andes: Lithium Mining at Salar de Olaroz-Cauchari and Salinas Grandes," *Die ERDE*, 2021, 1–17, https://doi.org/10.12854/erde-2021-515.

arduous. The CEO of an exploration company, operating across provinces in Argentina, noted that this process posed significant delays—spanning two years and approximately 28 meetings and presentations—because certain stakeholders have consistently refused to sign the necessary documents to advance to the UGAMP stage in Jujuy. According to this interviewee, when prospecting in the neighboring province of Salta, the company was able to secure drilling permissions for a project in just two weeks through a much more streamlined process in that province.

The community pushback that this interviewee describes occurs in the Salinas Grandes-Guayatayoc area (see figure 3.1). Protests against lithium in Salinas-Grandes garnered global attention for the social protest of indigenous groups defending land rights in mid 2023.[19] Dorn[20] argues that it is not lithium extraction in general that creates the conflict, but rather the historical erasure and dispossession of land that creates a strong desire for self-determination and autonomy as the present-day lithium landscape unfolds.[21] Lithium exploration in this region represents a continuation of historical indigenous erasure and oppression for a community that has been defending land claims in the region

[19] "Argentina: The Scramble for Lithium Threatens the Rights of Indigenous Peoples in Jujuy," International Federation for Human Rights, accessed December 14, 2024, https://www.fidh.org/en/region/americas/argentina/argentina-the-scramble-for-lithium-threatens-the-rights-of-indigenous; Felix Malte Dorn, "Inequalities in Resource-Based Global Production Networks: Resistance to Lithium Mining in Argentina (Jujuy) and Portugal (Região Norte).," *Journal Für Entwicklungspolitik: JEP. 37. 70-91. 10.20446/JEP-2414-3197-37-4-70.*, n.d.

[20] Dorn and Dorn.

[21] In this statement, I do not suggest that these sentiments are absent in the department of Susques, but rather the Salinas-Grandes these communities demonstrated relative political and economic leverage, and ability to mobilize protest mining industries in 2023 prior to Jujuy province limiting protest and free speech (through a series of reforms, discussed in depth below).

for hundreds of years.[22] Yet, just 80 kilometers to the west, in the department of Susques, located near the Olaroz-Cauchari mines, there has been a different response— one that has not made headlines. In the department of Susques, indigenous communities largely cooperate with mining activity, exemplified by the lack of protest surrounding mining at the Olaroz-Cauchari and Minera Exar mines. While some protest movements do appear in these communities, a culture of negotiation dominates.

For the purposes of this study, I focus on the Olaroz-Cauchari operations and the surrounding regions in Jujuy province, due to the relative acceptance of lithium mining activity and the prolific expansion of activity there. While the protests and dynamics that emerge around the effort to mine lithium near Salinas Grandes region are important, there is existing significant scholarly research on this region[23] and social pushback to mining[24] and additionally, other scholars have compared the two mining regions within Jujuy and their differing responses.[25] The expansion and legitimation of mining in the Olaroz-Cauchari/Susques region is particularly interesting for understanding how lithium extraction can proliferate, with scholarship identifying that mining in this region may be further legitimized

[22] Dorn and Dorn, "Changing Territorialities in the Argentine Andes"; Deborah Pragier, "Comunidades Indígenas Frente a La Explotación de Litio En Sus Territorios: Contextos Similares, Respuestas Distintas," *Polis (Santiago)* 18, no. 52 (January 2019): 76–91, https://doi.org/10.32735/s0718-6568/2019-n52-1368.

[23] Pragier, "Comunidades Indígenas Frente a La Explotación de Litio En Sus Territorios."https://doi.org/10.32735/s0718-6568/2019-n52-1368.

[24] "Tackling Lithium Rush: Salinas Grandes in Danger in Salta and Jujuy, Argentina | Cultural Survival," June 21, 2024, https://www.culturalsurvival.org/es/news/enfrentando-la-fiebre-del-litio-salinas-grandes-en-peligro-en-salta-y-jujuy-argentina; Dorn, "Inequalities in Resource-Based Global Production Networks: Resistance to Lithium Mining in Argentina (Jujuy) and Portugal (Região Norte).."; "Argentina."

[25] Pragier, "Comunidades Indígenas Frente a La Explotación de Litio En Sus Territorios"; Dorn and Dorn, "Changing Territorialities in the Argentine Andes."

through framing extraction within green development narratives.[26] For this reason, this region of Jujuy is most useful for exploring the extent to which the locale of extraction impacts the dynamics of extraction and the relative sustainability of extractive operations.

The entire Susques department, and Salar de Olaroz-Cauchari, sits within the Puna de Atacama, one of the Andean highlands' most water-scarce zones, characterized by minimal vegetation consisting of dispersed grasses and shrubs. These environmental constraints necessitate large land areas for the predominant economic activity: herding llamas, goats, and sheep. These animals primarily provide wool, leather, and meat for both subsistence needs and commercial exchange. Göbel, writing on the region, describes it as existing in a historic "vacuum" of the state, where essential infrastructure is lacking.[27] Many households employ diverse income approaches, including temporary or permanent wage employment, including mining.[28]

[26] Felix Malte Dorn and Kristina Dietz, "Legitimising Lithium Mining: Global Energy Transition and Green Developmentalism in Jujuy, Argentina," *European Review of Latin American and Caribbean Studies*, no. 118 (December 17, 2024): 43–66, https://doi.org/10.32992/erlacs.11121; Axel Anlauf, "Greening the Imperial Mode of Living? Socio-Ecological (in)Justice, Electromobility, and Lithium Mining in Argentina," in *Fairness and Justice in Natural Resource Politics*, ed. Melanie Pichler, Routledge Explorations in Environmental Studies (London ; New York: Routledge, Taylor & Francis Group, 2017), 164–80; Martín Obaya, Andrés López, and Paulo Pascuini, "Curb Your Enthusiasm. Challenges to the Development of Lithium-Based Linkages in Argentina," *Resources Policy* 70 (March 1, 2021): 101912, https://doi.org/10.1016/j.resourpol.2020.101912Dorn and Dietz, "Legitimising Lithium Mining"; Anlauf, "Greening the Imperial Mode of Living? Socio- Ecological (in)Justice, Electromobility, and Lithium Mining in Argentina"; Obaya, López, and Pascuini, "Curb Your Enthusiasm. Challenges to the Development of Lithium-Based Linkages in Argentina."

[27] Barbara Göbel, "La minería del litio en la Puna de Atacama: interdependencias transregionales y disputas locales," *IBEROAMERICANA* Vol. 13 (June 11, 2014): 135-149 Páginas, https://doi.org/10.18441/IBAM.13.2013.49.135-149.

[28] Göbel, "La Arquitectura Del Pastoreo."

This region has a long history of mining that extends long before the global lithium boom.[29] Communities were employed by Mina Providencia, a copper mine in the north of the department of Susques, as well as Mina Pirquitas, a silver, tin and zinc mine in the adjacent department of Rinconada.[30] However, when these mining ventures ground to a halt, communities suffered and people relocated, looking for economic and educational opportunities elsewhere. When lithium prospecting in the region began in the early 2000s, according to interviews, these economically disadvantaged communities were intrigued and surprised to be contacted by interested firms.[31] Given the opportunity to engage with the prospecting and extraction process, some scholars documenting extraction dynamics in the region argue there is a greater sense of agency from local communities, as mineral extraction is viewed as an economic opportunity.[32]

The first commercial project at Salar de Olaroz-Cauchari involved Sales de Jujuy, a joint venture between an Australian company and Toyota Tsusho, and began production in 2014, expanding through to 2025. In 2023, Minera Exar began pre-commercial operations, partnering China's Ganfeng Lithium and US-based Lithium Americas.[33] More plans for expansion of these projects continue into 2025 and beyond, as producing mines look to expand operations. Interviews and fieldwork conducted

[29] Nacif, "Litio en Argentina: de insumo crítico a commodity minero. Trayectoria socio-técnica de los yacimientos litíferos de la Puna (1930-2015)"; Göbel, "La minería del litio en la Puna de Atacama"; Dorn and Dietz, "Legitimising Lithium Mining."

[30] Dorn and Dorn, "Changing Territorialities in the Argentine Andes."

[31] Dorn and Dorn.

[32] Dorn and Dietz, "Legitimising Lithium Mining."

[33] USGS, "Mineral Commodity Summary- Lithium 2022."

in this region uncover that Jujuy officials governing the expansion of lithium in the region want direct foreign investment, arguing that "mining royalties are not the business."[34] This approach concludes that the main economic benefit for the region should be acquired through the employment of local contractors and local labor, rather than through mining royalties leveraged against firms operating in the region. This approach is meant to attract private foreign investment but has left local communities without pathways for economic development or tangible benefit from mining activity on their land. Some community members in the department of Susques are employed by the mining operations, but only around 30 percent of the population benefits from these mining activities. Without leveraging taxes on companies mining in the area, rural communities lack proportional economic benefit from the province's pro-mining stance. Dorn and Dietz[35] find that this region has legitimized mining through both "active consent" from certain community members and "passive resignation" from others. As one community representative stated in fieldwork from August 2019: "We cannot say no anymore. The projects are there, now we have to make the best of the situation."[36]

Water Usage, Concerns and Regulation

Within the Olaroz-Cauchari basin (see figure 3.2), communities, corporations and wildlife must all compete for increasingly scarce water resources. This part of Argentina is the most arid in the entire

[34] Dorn and Dietz, "Legitimising Lithium Mining."

[35] Dorn and Dietz.

[36] Quoted from interview with a treasurer of indigenous community, Susques, August 2019, by Dorn and Dietz.

country.[37] As lithium operations have continuously expanded, so has water consumption and the concerns of surrounding communities about access to freshwater.

Two operations, Minera Exar and Sales de Jujuy, produce lithium carbonate in the region. The Sales de Jujuy project draws its freshwater from the Archibarca River underground aquifer and consumes about 30% of all available water in its basin. To put this consumption[38] into perspective, the mine's annual water usage is equivalent to the water consumption of 32,238 people— roughly eight times the current population of the entire Susques department where the mine operates, which has only 3,980 inhabitants.[39] In addition to the water usage by Sales de Jujuy, neighboring project, Minera Exar, looks to produce over double what Sales de Jujuy produces, reaching 40,000 tons annually when at full production capacity (as of 2024, producing at 70%). The metrics on Sales de Jujuy and the annual water usage, only include fresh water, in the production process of lithium carbonate. However, there are other concerns that arise beyond just the fresh-water usage, as brine-evaporative processes pump brine from deep underground and evaporate liquid through the refining process.

[37] "Capitulo 4:DIAGNOSTICO DE LA DESERTIFICACION," Argentina.gob.ar, accessed February 24, 2025, https://www.argentina.gob.ar/.https://www.argentina.gob.ar/"Capitulo 4:DIAGNOSTICO DE LA DESERTIFICACION."

[38] This water is primarily used in two key processes: polishing (where freshwater preconditions concentrated brine by adjusting temperature and pH) and lithium carbonate precipitation (where freshwater is used to prepare soda ash solution and purify the final product).

[39] Walter Fernando Díaz Paz et al., "The Water Footprint of Lithium Extraction Technologies: Insights from Environmental Impact Reports in Argentina's Salt Flats," *Heliyon* 11, no. 4 (February 2025): e42523, https://doi.org/10.1016/j.heliyon.2025.e42523.https://doi.org/10.1016/j.heliyon.2025.e42523Díaz Paz et al.

Figure 3.2 — Map of Olaroz-Cuacharí Water Basin and neighboring Basin in Jujuy

Source: Global Press Journal, 2024[40]

Depending on the concentration of lithium in brine deposits, the amount of evaporation differs. At the Minera Exar operation, the initial concentration of lithium in the raw brine is 500 ppm, and the presence of more impurities requires additional steps and increased energy and reagent usage to produce a specific unit of lithium carbonate. As such, more evaporation steps are required to refine the lithium carbonate equivalent (LCE). This operation evaporates 289 cubic meters of water per ton of LCE produced. In contrast, at the neighboring project, Sales de Jujuy, the concentration of lithium in this brine is higher, at around 600-700 ppm, with this assumption that evaporative water consumption at this operation is slightly less. However, the two projects combined pumped around 12.2 billion liters of

[40] Lucila Pellettieri, "Lithium Mining Leaves Towns Dry," Global Press Journal, September 25, 2024, https://globalpressjournal.com/americas/argentina/lithium-mining-leaves-towns-dry-in-argentina/.

brine in 2023 alone, resulting in concerns about the equilibrium between underground brine and freshwater that allows the environment to sustain itself.

Due to the relatively low population density of the region and pro-mining stance of the province, there has been little done to regulate these firms' water use. The stark divergence between government and scientific perspectives on water governance in Argentina's lithium sector reveals a troubling disconnect in resource management. Government and corporate entities monitoring and permitting the expansion of lithium extraction outright deny the negative impacts on water supply. In a report from the Jujuy government in August 2023, released with the intention to "debunk myths" about lithium and water supply, they write: "it is false to say that the exploration and/or production of lithium carbonate consumes the water available to the communities, since the water for [local] consumption comes from other sources, which are not affected by the projects."[41]

Yet, in scientific and academic circles, concern is real. Argentina's Environment and Natural Resources Foundation (FARN) modeled the predicted impacts of lithium mining in 2018, in the Puna region's Olaroz-Cauchari watershed. Finding that the massive pumping of brine from Susques department — which began in 2015 — is likely to pull the nearby fresh water toward the salt flats, where it would become irreversibly salinized. The study also found that the levels of the Olaroz-Cauchari watershed will almost certainly drop, causing springs, lakes, lagoons and wells to dry up.[42] These predictions are proving to be true, based on research conducted by journalists and scientists, where

[41] Gobierno de Jujuy, "Derribando Mitos Sobre El Agua y El Litio," August 2023.
[42] Pía Marchegiani, Jasmin Höglund Hellgren, and Leandro Gómez, "Lithium Extraction in Argentina: A Case Study on the Social and Environmental Impacts," *Fundación Ambiente y Recursos Naturales*, n.d.

communities are expressing concrete concern about the increasing desertification [43] and lack of recognized water rights by the government of Jujuy. As mining activity has consistently intensified from 2015 to present day, places where animals once found water are dry and the pastoral communities nearby are suffering.[44]

While scientific articles and local communities consistently raise urgent concerns about water consumption and environmental impacts, government reports show remarkably little attention to water-related issues, focusing instead on global markets and economic development.[45] In a bibliometric review conducted by Díaz Paz et al., the government was found to be "the least concerned about water and the socio-environmental impacts of lithium mining," despite scientific evidence indicating that lithium extraction requires between 50-500m^3 of water evaporation and 5-50m^3 of freshwater consumption per ton of lithium carbonate. This misalignment has led to criticism about the regulatory framework for Argentina's lithium, highlighting how Jujuy's pro-mining policies favor economic imperatives over environmental protection and community water rights in these lithium-rich regions.

A significant concern involves how resource categorization manipulates water access rights. Mining corporations have strategically created the term "industrial water" — a classification without scientific basis — to distinguish certain freshwater sources from those designated as "drinking water." This industry-invented terminology refers to fresh water that does not meet potability standards for

[43] Pellettieri, "Lithium Mining Leaves Towns Dry."

[44] Walter Fernando Díaz Paz et al., "Lithium Mining, Water Resources, and Socio-Economic Issues in Northern Argentina: We Are Not All in the Same Boat," *Resources Policy* 81 (March 2023): 103288, https://doi.org/10.1016/j.resourpol.2022.103288.

[45] Díaz Paz et al.

human consumption.[46] However, these same water sources are traditionally utilized by local communities for agricultural needs and livestock. By applying this "industrial water" designation, mining operations can extract substantial quantities while claiming they are not competing with community water requirements. This linguistic framework effectively legitimizes excessive water appropriation that would otherwise be recognized as encroaching on community resources. José Gómez, secretary of Mining and Hydrocarbons of Jujuy province, says there are more than 70 monitoring points around the basin to ensure the mining does not lead to an underground mixing of saltwater and freshwater, yet confirmed in an interview that "industrial water" is the same thing that local communities use to raise livestock and consume as drinking water.[47]

In Jujuy, a governing body allocates water permits but does so without concern for the future depletion of water resources. The body is called, La Dirección de Recursos Hídricos (Water Resource Directorate) and the directorate has favored corporate water interests over the basin's actual capacity. The directorate grants permanent concessions to mining companies, lasting 40 years, with the directorate claiming that it will not be responsible for lack or decrease in water flow due to natural causes. These policies ensure the impunity of officials for later consequences while granting potentially unsustainable permanent water rights to lithium companies to operate in the region.[48]

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[46] Fresh water has a total dissolved solids (TDS) level of less than 1,000 parts per million (ppm). TDS measures the number of dissolved particles in water. Brackish water: 1,000 to 10,000 ppm, Saline water: 10,000 to 35,000 ppm. This "industrial water" has greater than 1,000 ppm TDS, yet, communities use this water for livestock purposes and drinking water.

[47] Pellettieri, "Lithium Mining Leaves Towns Dry."

[48] Jujuy Dice, "Conceden Uso de Agua En La Puna Jujeña Para La Minería Sin Importar La Falta o Disminución - Jujuy - Jujuy Dice, Jujuy, Argentina," Jujuy Dice, Noticias de Jujuy, Argentina, accessed March 11, 2025, https://www.jujuydice.com.ar/noticias/jujuy-3/conceden-uso-de-agua-en-la-puna-jujenia-para-la-mineria-sin-importar-la-falta-o-disminucion-55540.

These environmental barriers have the potential to halt progress of lithium extraction due to protest, however, the province of Jujuy has made significant progress in limiting the capacity of protest movements following the summer of 2023. Reforms were passed by Governor Morales of Jujuy province in 2023 that sought to criminalize public protests and restrictions on freedom of expression, petition and association, as well as revised legal mechanisms aimed at facilitating access to land for multinational lithium-producing companies.[49]

Green Developmentalism Narratives and the Future of Lithium in Jujuy

These controversial reforms affected private property rights and the provincial government's authority to declare "public utility" lands. The reforms were viewed by some as an attempt to circumvent Indigenous territorial rights. Meanwhile, the province promotes this decision as part of an ambitious development initiative, including South America's first Li-ion battery factory in Perico Industrial Park, the Cauchari Solar Park, and autonomous solar villages, as exemplified by Olaroz Chico near the first lithium extraction project.[50] Further investigating the proliferation of lithium extraction in the Salar de Olaroz-Cauchari region, Dorn and Dietz argue that lithium extraction is legitimized

[49] Amnisitía, "Organizaciones de Derechos Humanos Rechazan El Proceso de Reforma Constitucional En La Provincia de Jujuy," Amnistía Internacional Argentina | Defendemos los derechos humanos, June 14, 2023, https://amnistia.org.ar/organizaciones-de-derechos-humanos-rechazan-el-proceso-de-reforma-constitucional-en-la-provincia-de-jujuy/.https://amnistia.org.ar/organizaciones-de-derechos-humanos-rechazan-el-proceso-de-reforma-constitucional-en-la-provincia-de-jujuy/Amnisitía.

[50] "Embassy to the European Union | Governor Gerardo Morales Visits Europe to Advance Renewable Energy and Lithium Investment Projects in Jujuy," accessed February 24, 2025, https://eceur.cancilleria.gob.ar/en/governor-gerardo-morales-visits-europe-advance-renewable-energy-and-lithium-investment-projects.

through the creation of "green developmentalism" narratives that combine the need for economic development and industrialization with climate solutions.

Currently, the refined lithium commodity extraction in the Salar de Olaroz-Cauchari mines is primarily exported from the Angofasto port in Chile, some 530 km away to provide for LIB production networks in China and the US primarily.[51] However, the Jujuy government has placed significant emphasis on expanding domestic battery production and other more "value-added" production of lithium products, rather than solely exporting the commodity. Their core rationale is that producing lithium carbonate and end-products within the province would generate greater economic benefits than simply exporting it as a raw commodity. To this end, provincial authorities have proactively sought partners capable of providing lithium-ion battery (LIB) manufacturing technology for implementation in Jujuy.[52] This development approach has garnered substantial backing from academic circles,[53] yet fails to see practical implementation due to the high level of foreign investment and Argentina's far less-developed technologies for producing end-stream lithium products.

Obaya et al.[54] finds that Argentina faces barriers towards developing these "forward-based linkages" and instead proposes that Jujuy province could benefit from focusing on "backward linkages"

[51] Lithium Americas, "Updated Feasibility Study and Mineral Reserve Estimation to Support 40,000 Tpa Lithium Carbonate Production at the Cauchari-Olaroz Salars, Jujuy Province, Argentina," TECHNICAL REPORT, 2020.

[52] Anlauf, "Greening the Imperial Mode of Living? Socio- Ecological (in)Justice, Electromobility, and Lithium Mining in Argentina."

[53] Obaya, López, and Pascuini, "Curb Your Enthusiasm. Challenges to the Development of Lithium-Based Linkages in Argentina."

[54] Obaya, López, and Pascuini.

meaning efficient and sustainable practices for extraction of lithium. This would include initiatives taken locally, such as geological studies; extraction and processing technologies; lithium products; and local suppliers.[55] These initiatives would ideally increase local engagement in the extraction processes and improve local capabilities through both research and by including local research institutions in the industry development. SEGEMAR, (the Argentine Mining Geological Service) and geologists from the UNJU (National University of Jujuy) have independently conducted studies on the origin, hydrogeology, and recharge sources of lithium-rich salt flats. Additionally, the SEGEMAR developed a lithium map of the region in collaboration with the geological services of China and conducted a hydrogeological study of the Puna basins jointly with the United States Geological Survey.[56]

Yet, despite these independent efforts, Jujuy province and the Puna region lack the resources and capabilities to work to regulate and cooperate on backward linkage development. Additionally, there is little incentive given the province's liberal approach to foreign investment, and lack of oversight for these corporations that prevents this development. Transnational mining corporations have little to no reason to engage with local communities and institutions when firms can export the raw lithium at low cost without having to pay royalties to the region or be subject to federal oversight.

[55] Obaya, López, and Pascuini.

[56] Obaya, López, and Pascuini.

Key Findings

This chapter reveals how Jujuy's provincial governance has attracted foreign lithium investment while creating unaddressed environmental and social challenges. The regulatory environment, shaped by historical legacies and export-oriented companies, impedes sustainable extraction. Government narratives use "green developmentalism" to legitimize operations despite scientific evidence of water depletion. Despite aspirations for value-added production, the reality shows minimal local economic benefits beyond limited employment. Jujuy's historical context and provincial autonomy prioritize extraction over environmental protection and community water rights. These findings illuminate how extraction dynamics unfold when export priorities overshadow environmental and social considerations, begging the question of what development actually looks like, and providing context for comparison with the Nevada case study

CHAPTER FOUR: THE CASE OF NEVADA

To visualize extractive spaces not only as terrains from which minerals are extracted, but also as spaces where such activities are conceived, planned and legitimized.

—Dietz and Engels, "Contested Extractivism, Society and the State: An Introduction"[1]

Introduction

This chapter examines lithium extraction in Nevada, United States, providing the second empirical case for this comparative study. Nevada has emerged as a focal point for domestic lithium production in the United States, particularly as the nation seeks to secure critical mineral supply chains for the energy transition. This chapter analyzes the regulatory frameworks, extraction technologies, environmental impacts, and community responses surrounding lithium development in Nevada, with particular attention to the development of the new Thacker Pass project and the existing Silver Peak project---the only currently producing project in Clayton Valley. Like the preceding chapter on Argentina, this analysis interrogates how the locale of extraction shapes the dynamics that emerge around lithium development, exploring the interplay between federal and state governance structures, corporate strategies, environmental concerns, and community engagement. The Nevada case offers an instructive contrast to Jujuy, as it represents extraction in a developed economy with different regulatory traditions, Indigenous relations, and water governance regimes. This chapter builds on the analytical framework established in Chapter Three, allowing for subsequent comparative analysis in Chapter Five

[1] Kristina Dietz and Bettina Engels, "Contested Extractivism, Society and the State: An Introduction," in Contested Extractivism, Society and the State, ed. Bettina Engels and Kristina Dietz (London: Palgrave Macmillan UK, 2017), 1–19, https://doi.org/10.1057/978-1-137-58811-1_1.

of how extraction dynamics differ across these distinct contexts and what implications this holds for sustainable lithium development globally.

Methodology

This study employs a multi-method approach to analyze lithium extraction dynamics in Nevada. While maintaining methodological consistency with the Argentina case study for comparative purposes, this chapter incorporates additional primary data collection through key informant interviews. Between December 2024 and March 2025, I conducted 15 semi-structured interviews with stakeholders involved in Nevada's lithium sector, including regulatory officials from the Bureau of Land Management and Nevada Division of Minerals, corporate representatives from operating lithium companies, environmental advocates, tribal government representatives, and independent scientific researchers monitoring environmental impacts. These interviews, lasting between 45-90 minutes each, were conducted remotely via phone or video call. All interviews were recorded with consent, transcribed, and coded using thematic analysis techniques to identify recurring patterns, points of tension, and areas of consensus among different stakeholder groups.

As with the Argentina case, this chapter also systematically analyzes existing scholarly literature, policy documents, environmental impact statements, regulatory frameworks, and legal decisions that have shaped mining governance in Nevada. This includes federal permitting processes under the National Environmental Policy Act (NEPA), tribal consultation requirements, water appropriation procedures under Nevada state law, and county-level land use planning documents. I analyze these materials for how they structure relationships between different governance scales and stakeholders in

the lithium extraction process. Additionally, I incorporate quantitative metrics on water usage, land disturbance, and projected economic impacts to contextualize qualitative findings.

To ensure analytical validity, I triangulate findings across multiple data sources, comparing interview accounts with documented regulatory processes and independent scientific assessments. This approach allows me to identify both formal governance structures and informal practices that characterize lithium extraction in Nevada, providing a comprehensive empirical foundation for the subsequent comparative analysis with the Jujuy case study.

Nevada's Role in the Emerging Lithium Market

Nevada is home to the only operating lithium mine in the United States, Silver Peak Mine, located in Clayton Valley, NV. This mine has been operating since 1964, and has changed ownership, now run by Albemarle Corporation. The mine has been producing lithium throughout the latter half of the 20th century, prior to lithium being positioned as a mineral of global importance to the energy transition and technological revolution. Yet, Silver Peak mine cannot meet the domestic demand for lithium alone. In 2021, the United States contributed merely 5,000 metric tons to global lithium production of approximately 185,000 tons. China currently dominates the US lithium supply chain, creating significant strategic and economic dependencies.[2] The expanding lithium market has contributed to rising costs for lithium battery-powered products in the American consumer market.

[2] Richter, "Where Does the US' Get Most of Its Lithium-Ion Batteries?," World Economic Forum, March 15, 2023, https://www.weforum.org/stories/2023/03/charted-where-does-the-us-lithium-battery-supply-come-from/.https://www.weforum.org/stories/2023/03/charted-where-does-the-us-lithium-battery-supply-come-from/Richter.

The Chinese-American lithium battery trade reached $9.3 billion in 2022, encompassing hundreds of millions of individual battery units.

As lithium battery integration continues to expand across diverse product categories, developing robust domestic production capabilities would serve multiple strategic interests. Enhanced domestic lithium production would reduce foreign dependencies, potentially mitigate supply chain vulnerabilities, stabilize prices, and provide American consumers with more competitively priced lithium-containing products. A USGS report from August 2019[3] identified twenty significant lithium-bearing geological formations, extraction operations, and documented lithium concentrations (including both established reserves and potential resources). This comprehensive assessment encompasses localities that contain verified lithium resources exceeding 15,000 metric tons of lithium metal. These lithium-rich areas are geographically distributed across five states: Arkansas, California, Nevada, North Carolina, and Utah, with Nevada emerging as the focal point for current development activities and future production potential. Thirteen out of the twenty sites mentioned are located within Nevada's borders, spurring prospecting interests from mining companies across the state.[4] While other states have also experienced increased lithium exploration, Nevada has been poised as a key player in increasing domestic production of lithium for domestic markets. Economic and strategic considerations

[3] Nick A Karl et al., "Lithium Deposits in the United States" (US Geological Survey, 2019), https://doi.org/10.5066/P9ZKRWQF.https://doi.org/10.5066/P9ZKRWQFKarl et al.

[4] Bill Dentzer, "Nevada's next Boom: Demand Poised to Spur Silver State's Lithium Production," *Las Vegas Review-Journal* (blog), October 3, 2021, https://www.reviewjournal.com/local/local-nevada/nevadas-next-boom-demand-poised-to-spur-silver-states-lithium-production-2451259/.

are driving increased interest in developing Nevada's lithium resources as part of a broader effort to secure critical mineral supply chains for the United States.

Extraction in Nevada — From Gold to "White" Gold

Nevada got its nickname, "The Silver State" due to its long legacy of silver and other metal mining which has long been an identity and immense economic benefit for the state. Nevada's extractive industries have evolved through several distinct eras, beginning with Indigenous mining of turquoise, salt, and tool-making materials dating back 10,000 years. Modern mining commenced in 1849 with placer gold discoveries near Dayton, followed by rich silver deposits that dominated production through the late 19th century. During the early-to-mid 20th century, Nevada shifted toward base metals production (copper, lead, zinc, iron) driven by wartime industrial demands. The 1960s marked a return to precious metals dominance with the discovery of microscopic "invisible gold" deposits in northern and central Nevada counties, transforming the state into a global gold powerhouse by the 1990s.[5]

Mining activity in Nevada, has long been a point of contention for indigenous groups in the region, dispossessed of land and resources due to mineral prospecting and extraction. Expansion and exploration of mining required vast amounts of land, considered "scarce" in population or "barren." As a result, mining ventures, dating back to the era of Westward expansion, frequently dispossessed groups of people who had been living as stewards of the land for generations. Yet, for many rural counties in

[5] Nevada Bureau of Mines and Geology, "Mining History," accessed February 26, 2025, https://nbmg.unr.edu/mining/MiningHistory.html.https://nbmg.unr.edu/mining/MiningHistory.htmlNevada Bureau of Mines and Geology.

Nevada, extractive activity and the various forms it can take: oil, geothermal, mineral, metal and more, represents a source of economic prosperity and opportunity.[6]

Nevada's sole active lithium production facility operates in Clayton Valley, near Silver Peak (see figure 4.1), one of Nevada's oldest mining settlements dating to 1863. This historic mining district initially gained prominence for its gold and silver production before transitioning to lithium extraction. Mining activities in the area experienced significant disruption following a devastating fire that largely destroyed Silver Peak, leading to operational dormancy until 1966. That year marked a pivotal transition when Foote Mineral Company initiated lithium brine extraction operations in Clayton Valley, establishing what would become America's longest-running lithium production facility, later purchased by Albemarle who runs the facility today. Prior to the electric vehicle revolution that dramatically increased demand for battery materials, lithium from this operation primarily served pharmaceutical and industrial applications.[7]

[6] Jeff Fontaine, interviewed by Lena Hansen, February 4, 2025.

[7] De Winsor– Esmeralda County Commissioner, interviewed by Lena Hansen, January 29, 2025.

Figure 4.1— Map of significant lithium projects under development in Nevada

Source: Nevada Lithium

While there has not been significant pushback from local communities near the Silver Peak mine and no documented issues with water scarcity due to lithium mining, this monopoly on lithium and water rights might not last long. The mine has plans to double production by the end of 2025, but not without competition from other prospecting firms in Clayton Valley and across Nevada. The Silver Peak mine can be understood as an outlier in the emerging Nevada lithium landscape as the operations have slowly scaled to increase production, operating since the 1960s. Additionally, the lithium produced at Silver Peak is refined through brine evaporative processes, just like the projects in Jujuy province

discussed in the prior chapter. However, brine evaporative processes are extremely water intensive and can result in loss of groundwater over time.[8] As the most arid state in the nation, Nevada has held off on permitting for other brine evaporative lithium projects, and instead has prioritized open-pit clay deposits which are plentiful in the region.[9] Patrick Donnelly, at the Center for Biological Diversity stated in an interview that he believes that evaporative lithium brine projects will not be permitted in the state of Nevada moving forward due to not being cost efficient and state concern over water resources.[10] Instead, most of the projects proposed in Nevada are clay deposits, where extraction takes place in open-pit mines and the lithium compounds are acid-leached from the clay deposits.[11]

Regulatory Framework and Permitting Processes for New Lithium Projects

Nevada's lithium extraction is governed by a complex multi-layered regulatory system that spans federal, state, and local jurisdictions. The General Mining Law of 1872 established the foundational framework that continues to govern mineral extraction on federally owned public lands in the United

[8] Seyedkamal Mousavinezhad et al., "Environmental Impact Assessment of Direct Lithium Extraction from Brine Resources: Global Warming Potential, Land Use, Water Consumption, and Charting Sustainable Scenarios," *Resources, Conservation and Recycling* 205 (June 1, 2024): 107583, https://doi.org/10.1016/j.resconrec.2024.107583; Ye Zhang et al., "Systematic Review of Lithium Extraction from Salt-Lake Brines via Precipitation Approaches," *Minerals Engineering* 139 (August 1, 2019): 105868, https://doi.org/10.1016/j.mineng.2019.105868.https://doi.org/10.1016/j.mineng.2019.105868Mousavinezhad et al., "Environmental Impact Assessment of Direct Lithium Extraction from Brine Resources"; Zhang et al., "Systematic Review of Lithium Extraction from Salt-Lake Brines via Precipitation Approaches."

[9] Daniel Saftner, Kevin Heintz, and Ron Hershey, "Identifying Potential Hydrologic Impacts of Lithium Extraction in Nevada," n.d.

[10] For more information of brine-evaporative processes see: Mousavinezhad et al., "Environmental Impact Assessment of Direct Lithium Extraction from Brine Resources"; Zhang et al., "Systematic Review of Lithium Extraction from Salt-Lake Brines via Precipitation Approaches."

[11] Patrick Donnelly, interviewed by Lena Hansen, February 3, 2025.

States. This legislation enables private entities, both individuals and corporations, to establish mineral claims on federal lands where discoveries are made, without requiring prior governmental authorization—a mechanism that effectively incentivizes resource extraction on public domain lands. This permissive regulatory structure, coupled with subsequent technological innovations in extraction methodologies, facilitated expanded access to mineral deposits and reinforced extractivist approaches to resource development. The federal government's commitment to domestic mineral production was further codified in the Mining and Mineral Policy Act of 1970, which explicitly articulates a national policy to "foster and encourage private enterprise in the development of economically sound and stable domestic mining." This legislative history reflects the enduring priority placed on mineral resource development within the American federal land management system.[12]

This permissive structure has facilitated Nevada's resource boom, as Donnelly[13] noted that "over 100 lithium projects are being tracked in Nevada alone, due to the unique geography of Nevada [and] readily available deposits." The Bureau of Land Management (BLM) serves as the primary federal oversight agency for lithium projects, with additional roles played by the Fish and Wildlife Service, particularly regarding environmental impacts. Nevada has established itself as a leader in mining regulations across the country, particularly for precious metals over the past 30-40 years.[14] While hard rock mining has existed in the United States for over a century, Nevada currently maintains some of the

[12] Alannah Charlotte Brett et al., "Lithium Production in the United States: Socio-Technical Review of Sites, Environmental Impacts, and Social Acceptance," 2024, https://doi.org/10.2139/ssrn.4980674.

[13] Patrick Donnelly, interviewed by Lena Hansen, February 3, 2025.

[14] Jeff Fontaine, interviewed by Lena Hansen, February 4, 2025.

most robust mining regulations nationwide, developed through the Nevada Authority of Environmental Protection. The permitting process for lithium projects varies significantly depending on the extraction method and scale.

The Nevada Division of Minerals oversees exploration activities. From 2015 to present, the number of claims for lithium prospecting on federally owned lands has seen dramatic increases. As of September 2024, the Nevada Division of Minerals estimated 23,490 active, filed, and submitted placer claims, have been located in Nevada, presumably for lithium or lithium brine in 18 different hydrographic basins.[15] The process unfolds in a few different stages, first companies can file a "notice level activity" with the BLM that allows them to make claims through the National Environmental Policy Act (NEPA) process. Then, the Nevada Division of Minerals permits the exploration of certain claims. This process requires a cost analysis about what reclaiming the land after exploration would require, including reseeding and plugging wells to prevent groundwater evaporation. This division permits smaller exploration projects, usually involving less than five-acre feet (less than 1,629,255 gallons) of water in the exploration process. For larger commercial operations and the permitting of new mining operations, the full NEPA process applies, theoretically providing opportunities for public meetings and community input.[16]

As of 2024, only two projects have passed the NEPA review process, and are permitted to begin extractive activity, however many other projects are in the process of development (see figure 4.1). These

[15] "Lithium Claims," accessed February 28, 2025, https://data-ndom.opendata.arcgis.com/pages/lithium-claims.

[16] Robert Ghiglieri, interviewed by Lena Hansen, February 19, 2025.

two projects are: Thacker Pass, located in northern Nevada on the border of Oregon in Humboldt County; and Rhyolite Ridge, located in the same county as the Silver Peak mine, Esmeralda County, in southwest Nevada. These two sites of extraction have been met with heavy contestation for different reasons, but both have received loans from the Department of Energy to begin construction. Thacker Pass broke ground on construction in 2023, and Rhyolite Ridge just received approval to begin construction in October 2024.

Thacker Pass has been met with pushback from local indigenous communities. The nearest recognized tribe is the McDermitt Tribe, located to the north of the site. Issues arose with the permitting of the site due to a conflict in which the tribe claimed that the land had been an ancient burial site. The Thacker Pass project skipped over some vital aspects of the review process, primarily being engagement with local communities and opportunity for public meetings and input. The project went through the NEPA review process during the 2020 COVID lock down, and indigenous groups located near the site experienced severe impacts from the outbreak. As a result, these community members were not able to actively participate in discourse surrounding community acceptance and agreement about the operations. As a result, the BLM is being faced with accusations of not allowing the community to have free and informed consent surrounding the permitting of this project.[17] Other interviewees reflected similar concerns about the NEPA review process and its expedited nature when it came to the Thacker Pass project, noting that the project went through the whole NEPA process in under one year. Usually

[17] "New Report Finds Nevada's Lithium Mine Permit Violates Indigenous Peoples' Rights," *American Civil Liberties Union* (blog), accessed February 28, 2025, https://www.aclu.org/press-releases/new-report-finds-nevadas-lithium-mine-permit-violates-indigenous-peoples-rights.

for a mine of this complexity and scale, the review process would usually happen within a 3–5-year timeframe.[18]

Rhyolite Ridge, another project permitted recently, has received significant pushback due to concerns over water usage, and the project's potential to threaten a wildflower on the endangered species list. As a result, The Center for Biological Diversity moved to sue the operations and halt further construction of the site. These efforts were not met with action, as the Rhyolite Ridge project received one billion dollars' worth of funding from the Department of Energy to break ground. Both Rhyolite Ridge and Thacker Pass have gained significant attention due to their inaugural nature within the Nevada lithium landscape.

Beyond the current operations at Silver Peak, the lithium landscape in Nevada is unfolding in these contemporary contexts, with the initial projects setting the tone for all future Nevada lithium. Interviews revealed emerging alternative approaches that could potentially reshape extraction dynamics in Nevada. One significant development is the successful campaign for a mineral withdrawal at Ash Meadows, which Mason Voehl described as a "watershed moment" where both conservative rural communities and conservationists came together to protest mining that could threaten fragile ecosystems. This effort, driven by concerns about groundwater impacts on both the wildlife refuge and local communities, demonstrates how environmental protection and community interests can align to reshape extraction possibilities. Voehl argued that while there is bipartisan compromise on expanding

[18] John Hadder, interviewed by Lena Hansen, February 6, 2025.

Nevada lithium production, there is an opportunity to be selective about where and how these projects are approved.[19]

This case points toward a broader alternative vision for lithium governance that multiple interviewees described as "smart from the start" planning. Patrick Donnelly referenced the approach taken with solar energy in the California desert, where "a good faith effort was taken to identify areas where solar should be prioritized" and where it should not, due to ecological limitations and concerns in the region. In contrast, Lucia Patterson, at the Nevada Division of Minerals, described this vision as unrealistic and not accessible for the mining business because lithium deposits are not everywhere in contrast to solar energy, and that not all deposits are the same, or worth extracting from. Instead, she believes in the exploration process, and doing a full environmental evaluation of a region and providing prospectors with "considerations" for the region.[20] This proactive approach could potentially reduce conflicts by directing lithium development away from areas with critical water resources, endangered species, or cultural significance.

Across interviews, there appears to be a growing cooperation on "the new way to do conservation," as one that acknowledges both environmental protection needs and economic realities in rural communities. As Voehl explained, "we can no longer afford to do conservation in a zero-tolerance way, it does not feel morally responsible." Instead, conservation efforts must engage with "small, rural, impoverished, lacking in economic opportunity, frontline communities" to find solutions that address

[19] Mason Voehl, interviewed by Lena Hansen, February 5, 2025.

[20] Lucia Patterson, interviewed by Lena Hansen, February 19, 2025.

both environmental and social needs. While the efficacy of these claims remains to be seen, there is overlap between some conservation groups, pro-mining entities, local rural communities and regulatory agencies about the need for comprehensive planning and evaluation of new lithium projects.

Water Usage and Concerns

Water consumption emerges as perhaps the most contentious aspect of Nevada's lithium extraction, particularly given the state's status as the most arid state in the nation. These water concerns are particularly acute in Nevada's already water-stressed basins. Jeff Fontaine, of the Nevada Central Water Authority, explained that most of the basins are already over-appropriated. This means companies and individuals are allotted use of more water than the actual perennial yield, which represents how much the basin can sustain. Furthermore, several basins are over-pumped meaning that the water authority knows more water is being extracted than replenished. This existing water scarcity creates a fraught context for water-intensive mining operations. Particularly in Esmerelda and Nye counties, where most of the prospecting for new lithium projects is occurring.

Water concerns emerge around the effort to extract lithium, and in the process of exploration for new projects. Interviews revealed that water was a key issue for all stakeholders in the Nevada lithium industry, however, on the regulatory side, the Nevada Division of Minerals expressed confidence in their permitting process for exploration, explaining that exploration projects are carefully monitored through the borehole drilling process, ensuring that groundwater sources are not impacted. However, these claims are met with suspicion from environmental activists such as Mason Voehl,[21] of the Amargosa

[21] Mason Voehl, interviewed by Lena Hansen, February 5, 2025.

Conservancy, as he claims even the act of prospecting can threaten fragile ecosystems and groundwater in some regions, as bore holes can tap into the water table and cause irreversible damage. He claims that Nevada's 5-acre foot permitting process (meaning exploration projects that use less than 5-acre feet of water, undergo less regulation and environmental impact assessment) can be dangerous. His concerns arise from his work pursuing "mineral withdrawal"[22] in the region of Ash Meadows, in Amargosa Valley, NV, where even the act of exploration could have had devastating environmental impacts and the exploration permitting process failed to effectively mitigate this risk. As Nevada is a site for new prospecting, effective regulation of exploration and thorough environmental impact assessments become essential for the future of the industry.

On the extraction side, only one operation currently produces lithium, and is actively utilizing water rights to do so. In Clayton Valley, where Silver Peak mine operates, Albemarle Corporation claims that they use sustainable water governance practices, even in their brine evaporative process which pumps around fifteen billion liters of brine per year, since 2020. According to their website, this operation draws "from brine aquifers that are four times saltier than seawater. Because of this salinity, the brine cannot be used for human consumption or for agricultural purposes."[23] Yet, there are concerns about groundwater resources being drained through the emptying of underground briny aquifers, these

[22] "Under mining law, federal public lands managed by the BLM are by default open to mining as an appropriate use. A mineral withdrawal is a process through which specific areas of federally owned public lands are temporarily or permanently withdrawn from mineral entry. This means no new mining claims can be filed in a withdrawn area. This is typically done to protect certain values such as environmental, cultural, or recreational interests." Mason Voehl, "'What Is a Mineral Withdrawal?' Frequently Asked Questions," Amargosa Conservancy, February 1, 2024, https://www.amargosaconservancy.org/what-is-a-mineral-withdrawal-frequently-asked-questions/.

[23] "Silver Peak, NV, USA | Albemarle," May 22, 2024, https://www.albemarle.com/global/en/silver-peak.https://www.albemarle.com/global/en/silver-peak"Silver Peak, NV, USA | Albemarle."

concerns arising due to groundwater flowing into these emptied spaces, turning freshwater into non-potable briny liquid. For the most part, this operating mine has not been met with pushback from local communities but rather experienced relative levels of support from the sparsely populated rural Esmeralda County as it is a significant employer in the region.

There is documented competition and litigation against Albemarle's outsized water rights allocation for the only operating lithium mine in the area. SLB corporation has several claims in the region of Clayton Valley and is tied up in litigation against Albemarle. This corporation claims that Albemarle holding onto this water violates the "use it or lose it" rule of Western water law.[24] This Western water law rests on the idea that individuals and businesses cannot retain water rights indefinitely.[25] The rule aims to prevent speculation by entities that might hold onto an unused water right in hopes that its value will increase. In the case of the Silver Peak mine, Albemarle's water rights have seniority and therefore in the case of over-appropriation will be protected over more recently appropriated water rights. Yet, water governance issues are further complicated by strategic categorization of water resources. Similar to the "industrial water" designation observed in Argentina, Nevada mining operations may lease agricultural water rights from neighbors for mining purposes. This practice raises concerns about both the legitimacy of the water rights being transferred and the long-

[24] Daniel Rothberg, "Lithium Companies Fight Over Water in the Arid Great Basin," *Inside Climate News* (blog), April 8, 2024, https://insideclimatenews.org/news/08042024/nevada-great-basin-lithium-fight-over-water/.https://thenevadaindependent.com/article/in-remote-nevada-valley-a-race-for-more-lithium-comes-down-to-waterefbfbcRothberg; "In Remote Nevada Valley, Race for More Lithium Comes down to Water," The Nevada Independent, October 31, 2022, https://thenevadaindependent.com/article/in-remote-nevada-valley-a-race-for-more-lithium-comes-down-to-waterefbfbc.

[25] Research Division Legislative Council Bureau, "Water Policy and Issues in Nevada: Overview," December 2019.

term implications for agricultural communities. As Fontaine explained, "once you convert irrigation rights for agriculture to a non-irrigated land" groundwater resources can become threatened. As budding interest in Nevada lithium emerges, questions of what Nevada's water resource can sustain are becoming paramount in importance. While Albemarle denies any impact on surrounding aquifers, community members have expressed concern that regions where groundwater reserves used to be, they no longer can be found.

Silver Peak is an outlier in Nevada's emerging lithium extraction industry, as it utilizes brine-evaporative processes like those used in the Olaroz-Cauchari projects and across the lithium triangle. The water consumption of these processes differs based on the lithium concentration of the brine deposits, and it can range from anywhere between 9 to 24 cubic meters per ton of lithium carbonate, depending on the site. However, due to concerns over groundwater evaporation, land use, and the composition of lithium deposits in Nevada, brine evaporation processes are less attractive.[26] Other methods, such as clay-based lithium extraction and direct-lithium extraction from brine sources have gained attention in Nevada. All these processes require freshwater and energy, though with varying degrees of severity.

Clay-based extraction projects like Thacker Pass present different, but similar, concerns surrounding water-usage when compared to brine operations. There are different ways to extract lithium from clay, through either acid-leaching or roasting processes, with the former being the less

[26]Patrick Donnelly, interviewed by Lena Hansen, February 3, 2025.

water and energy intensive process[27] of the two. However, clay extraction demands freshwater at the extraction site—approximately 95 m^3 and 100 m^3 per ton of lithium carbonate equivalent (LCE), respectively. John Hadder of the Great Basin Resource Watch, explained that these operations require huge amounts of consumptive water use both in the process of making sulfuric acid to leach the lithium from the clay, and in the act of "dewatering." Dewatering is the act of removing water from open-pit mines to keep the workings dry. Concerns over lithium mining projects arise most critically when these operations attempt to go below the water table. This means that mining companies artificially lower the water table so that the working remains dry. The environmental impacts of this dewatering can persist long after mining ceases, with Hadder noting that the recovery of that water can often be over 100 years and often impacts the entire water table for a region including flowing springs.[28]

In Nevada, there are promising innovations in water treatment and recycling systems that present opportunities to substantially decrease water consumption. Lithium Americas plans to implement these technologies at their Thacker Pass project to recover and reuse water by eliminating impurities (primarily sulfate and carbonate salt byproducts) from wastewater (Lithium Americas, 2023). This innovation could potentially reduce water requirements for acid leaching processes by 80%, lowering consumption to roughly 20 m^3 per ton of LCE.

[27] For a comparison of clay processes and hard-rock processes with in depth life cycle and environmental impacts, see: Rob Ghiglieri, "Lithium Deposits of Nevada: Brine vs. Clay"; Venkat Roy, Mariappan Parans Paranthaman, and Fu Zhao, "Lithium from Clay: Assessing the Environmental Impacts of Extraction," *Sustainable Production and Consumption* 52 (December 2024): 324–32, https://doi.org/10.1016/j.spc.2024.11.008; Zhang et al., "Systematic Review of Lithium Extraction from Salt-Lake Brines via Precipitation Approaches."

[28] John Hadder, interviewed by Lena Hansen, February 6, 2025.

The emerging Direct Lithium Extraction (DLE) technology is promoted as a more water-efficient alternative to evaporation ponds.[29] This technology pulls lithium from brine reserves, but returns water back into aquifers, creating somewhat of a closed loop system.[30] Initiatives to implement DLE are appearing in Chile, Argentina, and China. In 2023, Livent Corporation invested approximately $5.5 million in DLE for its Argentine lithium operations, though these initiatives remain in early development stages. Concurrently, the US Department of Energy allocated $10.9 million to fund 10 projects across nine states focused on developing advanced technologies for extracting battery-grade lithium from domestic geothermal brines. Major brine lithium producers SQM and Albemarle are also directing significant investment toward Direct Lithium Extraction (DLE) initiatives in Chile. Successful implementation of DLE is exhibited by the company "Lanke Lithium" launched in China in 2017 with a total investment of $430 million and produced 20,000 t of battery-grade lithium carbonate. However, concerns remain about the implementation of this technology, including questions about what happens in the extraction and whether water is returned to where it came from. In a pilot test in Nevada, DLE methods demonstrated "lower direct land use, reduced water consumption, and lower greenhouse gas emissions," indicating their viability in water scarce regions,[31] yet scalability remains a question. However, Fontaine added that under "current Nevada law, closed loop systems do not need

[29] Mousavinezhad et al., "Environmental Impact Assessment of Direct Lithium Extraction from Brine Resources."https://www.kunr.org/local-stories/2024-08-30/new-lithium-mining-method-could-save-ground-water-resources-in-nevadaMousavinezhad et al.; "New Lithium Mining Method Could Save Ground Water Resources in Nevada," KUNR Public Radio, August 30, 2024, https://www.kunr.org/local-stories/2024-08-30/new-lithium-mining-method-could-save-ground-water-resources-in-nevada.

[30] Dustin Holcomb, interviewed by Lena Hansen, February 19, 2025.

[31] Mousavinezhad et al., "Environmental Impact Assessment of Direct Lithium Extraction from Brine Resources."

to be approved" for water rights, creating potential regulatory gaps. There are no DLE projects currently operating at scale in Nevada, however there is significant incentive to get this technology widespread to access brine resources in a regulatory environment that is unlikely to permit future evaporative brine projects moving forward.

The "Lithium Loop" and Economic Development Narratives

Nevada's approach to lithium extraction is increasingly framed within a broader economic development strategy centered on what Governor Lombardo has termed "the lithium loop."[32] This concept envisions Nevada as a hub for the entire lithium value chain, from extraction to processing, battery manufacturing, and recycling. As Rob Ghiglieri described it, the lithium loop represents "the idea of start to finish exploration to anode and cathode battery manufacturing, vehicle manufacturing, and battery recycling." This narrative bears striking similarities to the "green developmentalism" observed in Argentina, with state officials highlighting both economic opportunities and environmental benefits. However, the implementation between the two cases differs; this will be discussed in the following chapter.

[32] "Gov. Lombardo Holds Inaugural Nevada Lithium Summit," TWW, September 30, 2024, https://www.thewesternway.org/tww-blog/2024/9/27/gov-lombardo-hold-lithium-loop-conference; Ray Hagar Nevada Newsmakers, "Nevada Mining Head: 'Lithium Loop' Set for Major Expansion," accessed February 28, 2025, http://www.nevadaappeal.com/news/2024/jul/19/nevada-mining-head-lithium-loop-set-for-major-expansion/.http://www.nevadaappeal.com/news/2024/jul/19/nevada-mining-head-lithium-loop-set-for-major-expansion/"Gov. Lombardo Holds Inaugural Nevada Lithium Summit"; Newsmakers, "Nevada Mining Head."

The lithium loop concept has gained traction through initiatives like the recent Lithium Circular Economy Conference in April of 2024,[33] and the University of Nevada, Reno's designation as one of seven recipients of a National Science Foundation grant to establish supply chains. This concept arose from the need for a domestic supply chain for battery manufacturing, and further, made possible through mining companies partnering with battery manufacturers and automotive manufacturers to keep supply chains closer together in geographic distance. There is significant work being done to incorporate local knowledge and improve the scientific capabilities of local universities through this "lithium loop" concept. An exciting aspect of the "lithium loop" system arises from Nevada's simultaneous push to access geothermal renewable energy and solar. Due to this, the energy requirements for lithium extraction in Nevada, and the later production processes, could be provided through renewable sources. These energy prospects are exciting, especially when coupled with increased interest in more energy intensive processes, such as DLE.

However, interview subjects raised concerns about how benefits from this development would be distributed. Much of the growth in Reno, Las Vegas and Carson City has drawn people from the outside, increasing the economic prosperity of urban centers, but this raises concerns about creating peripheries for the rural communities sited near extraction. Furthermore, Mason Voehl noted that while state officials are enthusiastic about economic growth, "local communities do not share that enthusiasm," particularly regarding jobs. The rural communities of Nevada are relatively underwhelmed by the benefits of the lithium loop, as economic benefit seems to be consolidated in urban centers. However,

[33] "Nevada Lithium Circular Economy Conference," *Recharge Nevada* (blog), accessed February 28, 2025, https://rechargenevada.org/conference/.

in contrast to Jujuy, Argentina, Nevada charges mining royalties of 5% for mining companies with those proceeds being distributed directly to the rural counties where the mines are located, and the royalties contribute to the Nevada Department of Education fund. This fiscal policy was amended in 2021 with bipartisan support, increasing taxes on mining companies, which generated more revenue for rural mining counties. In 2019, the revenue from this "net proceeds" tax was over $61 million, and increased after 2021 reforms. While 90% of this revenue was generated by gold and silver mining in the state, the expanding lithium industry provides economic opportunity for the state and the rural counties in which lithium deposits are located.

The economic vision of the lithium loop also faces challenges regarding implementation and authenticity. Hadder expressed concern that rather than a true circular economy, the project could result in "a greenwashed version of circularity" that continues "to permit mining projects" without addressing long-term sustainability. He noted a disconnect between battery manufacturers and recyclers, with companies focusing more heavily on production rather than recycling viability for batteries.[34]

Key Findings

The dynamics of lithium extraction in Nevada reveal complex interplays between regulatory frameworks, water governance, economic development narratives, and emerging alternatives. The case demonstrates how the locale of extraction, and the ability of locale to develop value-chains while simultaneously expanding extraction has sustainability impacts. As lithium operations continue to expand across the state, competing visions of sustainable development have emerged. The dominant

[34] John Hadder, interviewed by Lena Hansen, February 6, 2025.

approach emphasizes rapid permitting without community consultation, and integration into global battery supply chains. Alternative perspectives advocate for more deliberate planning that protects critical environmental resources and ensures community benefits. The next chapter is a direct comparative analysis of the empirical data from chapters three and four, to draw conclusions about the viability of sustainable extraction.

CHAPTER FIVE: COMPARATIVE ANALYSIS AND IMPLICATIONS FOR SUSTAINABLE LITHIUM

Without data, you're just another person with an opinion.

— W. Edwards Deming, *Out of Crisis*[1]

Introduction

This chapter provides a comparative analysis of lithium extraction in Nevada and Jujuy, examining each cases' respective sustainability outcomes. The analysis evaluates environmental, economic, and social dimensions of extraction to determine relative sustainability and identify critical factors affecting long-term viability of lithium operations in each region. This analysis goes beyond current indicators to assess factors determining whether extraction practices can be maintained throughout projected operational lifecycles or whether they generate environmental degradation, social conflict, or economic instability that undermines continued extraction and production.

Comparative Framework and Methodology

This chapter employs a comparative methodology to analyze lithium extraction dynamics in Nevada and Jujuy. This analysis centers on concrete metrics and outcomes that determine the sustainability of lithium operations in both regions. The methodology combines qualitative and quantitative assessment, with discourse analysis framed by the field of political ecology to examine how

[1] William Edwards Deming, Out of the Crisis, MIT Press Ser (Cambridge: MIT Press, 2000), 35.

different governance structures, environmental conditions, and socio-economic contexts produce varying sustainability outcomes.

The comparative framework evaluates sustainability across three interconnected dimensions. Firstly, environmental sustainability, measured through water consumption rates per ton of lithium produced, evidence of ecosystem impacts, and effectiveness of monitoring and mitigation practices. Secondly, economic sustainability, assessed via economic multiplier effects, royalty and tax structures, local employment statistics, development of value chains, and long-term economic resilience indicators. Thirdly, social sustainability, evaluated through community acceptance indicators, benefit distribution mechanisms, effectiveness of consultation processes, and evidence of social conflict or cooperation.

This framework seeks to recognize that sustainability outcomes are not merely technical matters but are shaped by power relations, political decisions, and historical context. The analysis pays particular attention to how different actors—state agencies, corporations, communities, and environmental organizations—influence extraction practices and their sustainability implications.

Importantly, this analysis conceptualizes sustainability not just as a current state but as a predictor of long-term viability. It examines factors that either enhance or threaten the ability of lithium operations to function throughout their projected lifecycle. This forward-looking assessment considers how current practices create conditions that either support or undermine the long-term environmental, economic, and social viability of lithium extraction in each region. The comparative methodology uses a structured, focused comparison that systematically examines the same variables across both cases while maintaining sensitivity to context-specific factors. This approach enables identification of both generalizable patterns and place-specific dynamics that influence lithium sustainability in arid regions.

By comparing quantitative metrics (water usage rates, energy usage, economic returns) alongside qualitative indicators (governance effectiveness, community relationships, environmental management practices, regulation), the analysis provides a comprehensive assessment of factors shaping sustainable lithium development in Nevada and Jujuy.

Environmental Sustainability

To evaluate the relative environmental sustainability of these two operations, I compare environmental and ecosystem protection, water usage and water governance, and energy usage and sources across the two cases. An issue emerges around ecosystem destruction and creation of "sacrifice zones" in the process of expanding extraction to new geographies. To evaluate the environmental sustainability across these two cases, it is essential to compare how communities, governments and industry actors engage with the local environment and ecosystems.

Ecosystem Degradation and Safeguards

In the case of emerging interest in lithium in Nevada, multiple environmental justice and conservation groups, such as the Center for Biological Diversity, the Great Basin Resource Watch and the Amargosa Conservancy raised concerns about the expedited nature of lithium exploration and expansion. Due to federal mining laws which allow exploration on all federally owned lands, Nevada's fragile desert ecosystems are at risk to both exploration and exploitation due to the lithium rush. Interviews revealed that many of the proposed projects (i.e. Thacker Pass, Rhyolite Ridge) are in biodiverse areas, and based on environmental impact assessments around one quarter of the proposed projects could have severe environmental ramifications, while one quarter of the projects proposed

could be relatively benign.[2] Part of the concern around ecosystem degradation arises from the outdated mining laws that do not exclude delicate ecosystems from mining speculation, if located on federally owned land. As a result, been left in the hands of conservation organizations and indigenous leaders in the region to pursue litigation against exploration in regions where it could be devastating for certain species or water resources. Due to the actions of these non-profit environmental justice groups, Nevada was host to three groundbreaking litigation battles about how and where lithium extraction unfolds (Thacker Pass, Rhyolite Ridge and Ash Meadows). Interviews revealed that Nevada's current laws and approach to lithium expansion is outdated, but revisions and harm-reduction approaches to preserving fragile ecosystem health could create groundbreaking innovations in how exploration and extraction proliferates.

In Jujuy, there is a divergence in perspective on what the salt flats and surrounding ecosystems represent. In Jujuy and surrounding regions in the "Lithium Triangle" a dominant narrative emerged from governments and corporations to frame the salt flats as empty, barren or lifeless. As mentioned previously, this understanding is essential to legitimize immense extractive activity under the presumption of a land that had no value prior to extractive activity emerging. However, these notions are challenged by indigenous communities in Jujuy and across the region in Bolivia and Chile, who argue that lithium is not an ecologically sound commodity to extract. Actors resisting lithium projects are primarily led by indigenous groups who cite the salt flats as a source of life and a fragile ecosystem that has sustained their communities for millennia. Indigenous communities in this region have subsisted

[2] The other half were identified as having significant issues, but not immediately threatening ecosystems.

and survived in desert regions with little access to water, challenging this notion that these spaces were empty, barren or unproductive prior to the introduction of extractive activity. However, there are very few legal pathways for the contestation of lithium expansion in Jujuy, as the province has ultimate authority over mining claims, and their stance remains aligned with foreign investment and expanding the industry. This has conclusively meant oppressing indigenous voices and reforming laws to limit the legality of protest in the region.

In both cases, pro-mining regulation creates hurdles for the environmental sustainability of extraction, as new frontiers are sacrificed to provide for growing lithium demand. However, in the case of Nevada, it appears there are more effective pathways for resolution and negotiation as the landscape emerges. Jujuy, on the other hand, struggles with a regulatory structure reliant on resource dependent economies and ecosystem degradation as indigenous voices are increasingly silenced and devalued in the eyes of corporations and the provincial government. As Jujuy has a more developed lithium industry, with high stakes for both the provincial government and international investors, the feasibility of negotiation and the reconsideration of ecological impacts faces mounting opposition.

Water Usage and Governance

Water concerns emerge across both cases as the chief environmental concern. The reason for this is twofold: both regions are relatively arid, and lithium extraction is a water intensive process. Nevada, as the most arid state in the nation, looks to expand lithium amidst an extremely contentious water regulation landscape. Jujuy, in contrast, faces pushback from scientific communities and front-

line communities, yet it lacks adequate regulation and accountability to mitigate concerns over excessive water use.

As shown in, Table 5.1 the two cases diverge in their water usage requirements, relative aridity, and attitudes towards water conservation and usage. Lithium operations across the globe vary significantly in terms of freshwater usage, depending on the type of deposit, and the quality of the deposit. Jujuy brine operations use less water per ton of LCE, when compared to the Silver Peak mine, due to higher concentrations (ppm) of lithium in the brine solution. As a result, refining requires less processing to get the equivalent amount of LCE. The Silver Peak operation in Nevada, is a brine evaporative process and is immensely water intensive when compared to the operations in Jujuy, consuming over three times as much water per ton of lithium produced. In a region with very little rainfall, the fresh-water requirements combined with the high quantities of brine pumping required mean that the Silver Peak operation is hydrologically inefficient.

Table 5.1— Comparison of water use in lithium industries --- Nevada vs. Jujuy

Factor	Nevada, USA (Clayton Valley and other new projects)	Jujuy, Argentina (Olaroz-Cauchari Basin)
Dominant Extraction Method	Clay extraction, evaporative brine operation in Clayton Valley, DLE exploration	Evaporative brine, DLE exploration on Salar de Jama
Water governance and permitting body	Nevada Division of Water Resources (NDWR) (allocates water rights and permits for projects)	La Dirección de Recursos Hídricos
Avg. annual rainfall	261mm (10.3 in)	600mm (24 in)
Fresh water usage per ton of lithium carbonate equivalent produced (LCE), annual avg.	155,200 L/metric ton LCE (Silver Peak, Clayton Valley) Estimated— 40,218 L/metric ton of LCE (Thacker Pass at full operational capacity) Estimated — 960.3 L/metric ton of LCE (Rhyolite Ridge at full operational capacity)	46,718 L/metric ton of LCE (Sales de Jujuy) No data on fresh-water usage available at Minera Exar
Annual brine usage	15 billion liters (Silver Peak)	12.2 billion liters (Sales de Jujuy and Minera Exar combined)
Presence of community concern (on water usage)	Yes	Yes
Presence of government/corporate concern	Yes	No
Presence of water-saving technology investments	Yes	No[3]

[3] There are DLE projects under development in Jujuy province such as the project on the Jama Salt flat, however these projects are in the first stages of development. They are not associated with the Sales de Jujuy project or Minera Exar project. For more, see:

However, Silver Peak is the exception to the emerging rule in Nevada, as brine-evaporative processes are facing permitting pushback in Nevada. Due to the huge amount of freshwater and brine reserves required, in addition to massive land-use requirements, the state of Nevada has turned away from permitting the expansion of brine-evaporative lithium projects. Instead, Nevada has been permitting extraction from clay deposits, exemplified in the Thacker Pass project. This project began construction in 2024 and is expected to reach full capacity production (160,000 tons annually) by 2028. Based on predicted water use requirements and permitted water allocation, this project will use less water per ton of LCE than current brine operations in Jujuy. In addition to clay deposit prospecting in Nevada, new ways of conserving water in brine-extraction have emerged.

Albemarle's entrenched position at Silver Peak effectively creates a monopoly advantage through legacy water rights—not superior operational efficiency. This water allocation system, while designed to protect Nevada's scarce resources, inadvertently reinforces market concentration by privileging historical claims over innovation potential. The corporation SLB, and their litigation against Albemarle represents not just a corporate squabble but a fundamental challenge to this antiquated framework. Ironically, the very restrictions that threatened to exclude SLB from the market have catalyzed their technological pivot toward direct lithium extraction. This innovation was not merely an adaptive response but potentially industry-transforming, suggesting that regulatory constraints, when properly channeled, can accelerate rather than impede progress. The critical question remains whether Nevada's water governance structure will evolve to balance resource conservation with the enabling of transformative technologies that could ultimately reduce environmental impact.

Nevada's regulatory structure for water permitting has both encouraged exploration into clay-extraction and into technological innovations for direct lithium extraction to navigate water constraints. These shifts away from water-intensive methods seem to be heavily influenced by community, government and scientific concern over water. The water scarcity issue in Nevada is documented across newspapers, corporation responsibility reports and governmental regulation. As the lithium landscape emerges in Nevada, regulators, communities and corporations must make decisions and develop based upon a communally recognized resource scarcity.

In contrast, Jujuy, while facing many of the same concerns about water scarcity and depleting groundwater sources, shows a stark contrast in corporate and government response. Despite community and scientific concern about depleting freshwater resources and the impacts of brine pumping, the government of Jujuy fails to recognize these concerns or adjust water permitting structures accordingly. As such, these brine evaporative processes, Sales de Jujuy and Minera Exar have been permitted to expand operations without direct oversight on water-usage requirements. The categorization and governance of water resources differ significantly between regions. In Jujuy, mining corporations have strategically created the term "industrial water"—a classification without scientific basis—to distinguish certain freshwater sources despite these same water sources being traditionally utilized by local communities for agricultural needs and livestock. While there is a regulatory body in Jujuy for water permitting, La Dirección de Recursos Hídricos (Water Resources Directorate), this governing body favors mining claims over community access to water resources. At Sales de Jujuy, the project filed for water rights with the directorate and was allocated a 40-year permit with extremely favorable conditions

for the company and retained impunity for the regulators through a series of articles that shift blame away from the permitting agency in the case of future in decrease or lack of water resources.

Without comprehensive regulatory restrictions on water use, companies are incentivized to expand water-intensive lithium extraction operations despite the potential ecological impacts. In the Nevada case, stricter regulatory oversight on water allocation has been influenced by a confluence of concern from communities, corporations and government. This regulation has created a landscape in which firms looking to extract lithium resources must find pathways towards more sustainable water use and modernize operations to comply with the permitting requirements. In contrast, Jujuy continues to permit the expansion of water and land-intensive brine operations, creating sustainability obstacles as communities surrounding these extraction sites are deprived of water, and therefore the right to life.

Energy Usage and Emissions Concerns

There is considerable attention paid in both regions to "greening" the extraction processes of lithium. One way this is occurring is through the energy requirements for lithium extraction processes. In both Nevada and Jujuy, there has been significant investment in renewable energy sources, with firms looking to couple renewable energy to the requirements of lithium extraction. The energy dimensions of lithium production in Nevada and Jujuy reveal important differences in consumption patterns, energy sources, and integration with renewable generation that significantly impact environmental sustainability. These factors not only influence the carbon footprint of lithium operations but also their long-term viability in a decarbonizing global economy.

i. Energy Requirements by Extraction Method

The energy intensity of lithium extraction varies substantially between technologies employed in the two regions. In Jujuy, the brine evaporation operations at Olaroz-Cauchari rely primarily on solar evaporation for concentration, resulting in relatively low direct energy requirements of 1.8-2.5 MWh per ton of lithium carbonate equivalent (LCE). This process harnesses the region's intense solar radiation and high evaporation rates, with energy primarily consumed in pumping, processing facilities, and transportation. Due to Argentina's vast natural gas reserves, energy requirements for lithium in Jujuy are being met by a natural gas pipeline. This pipeline provides for the Minera Exar venture, and transports fuel to the project, provided by the company "Gas Atacama."

In contrast, Nevada's emerging clay-based extraction at Thacker Pass involves a more energy-intensive acid leaching process, requiring an estimated 5-7 MWh per ton of LCE. This higher energy demand reflects the mechanical crushing, chemical processing, and heating required to extract lithium from clay deposits rather than pre-concentrated brine. The Silver Peak operation, using traditional brine evaporation, has energy requirements more comparable to the Jujuy operations, though specific figures are not publicly disclosed. Direct lithium extraction (DLE) has been directly linked to minimal water use, but high energy consumption requirements. While Nevada looks towards limiting water consumption in the industry, the growing energy demand may be met by renewable energy sources such as solar, wind and geothermal that are expanding in the region. Nevada's relative infancy in the lithium market creates pathways for colocation of geothermal energy generation and simultaneous lithium extraction. Additionally, due to regional demand for lithium carbonate, interviews revealed that other

mining industries in Nevada and across the US, such as oil, look to extract lithium from the produced water generated from the mining process. This could dramatically decrease the demand for new extraction sites while supplying expanding demand for lithium, ultimately making lithium extraction more environmentally sustainable.

ii. Renewable Energy Integration

Jujuy province has developed the Cauchari Solar Park, a 300 MW facility that represents one of South America's largest solar installations. Provincial authorities have explicitly linked this renewable generation to their vision of "green lithium" production, though the direct integration of this solar capacity with lithium operations remains limited. The physical proximity of the solar park to lithium operations creates potential for more direct integration, but current operations primarily draw from the general electricity grid and natural gas resources. The park opened in 2023, and the provincial government highlights it as an economic development opportunity that will allow the lithium industry to expand. The solar park investment has been directly linked to the expansion of lithium in the region and the desire to provide for the energy requirements of both extraction and downstream development.

In Nevada, the state emphasized integration with the state's growing renewable energy portfolio, which reached approximately 30% of generation in 2023. Within increasing solar and geothermal energy generation in the region, nearby lithium extraction could draw directly from these renewable sources. The Thacker Pass project has announced plans to maximize renewable energy usage, potentially drawing from geothermal resources in northern Nevada and onsite solar generation, though specific

implementation details remain under development. New technological advancements are limiting the energy requirements of lithium extraction, with firms attempting to use heat-capture within the extraction process to make the energy requirements for certain projects net-zero. Geothermal is a particularly promising avenue for Nevada as there is potential for extracting lithium from geothermal brines while simultaneously generating energy.[4] Many of these projects are in the pilot stage, but these innovations present the opportunity to minimize energy costs, incentivizing further investigation and implementation. To further incentivize this development, Nevada and Jujuy could create economic tax incentives for firms to use renewable energy and for geothermal operations to co-locate lithium extraction from brines.

Economic Sustainability

I compare revenue distribution structures, value chain development and employment as factors that contribute to the long-term economic sustainability of lithium extraction in each case. In both cases, lithium has been framed within an economic development agenda, in which these regions are participating and benefitting from a growing "green" economy. Despite the presence of these "green developmentalism" narratives in both cases, the implementation and actualization of these ideals differs.

Revenue Distribution

The fiscal frameworks governing lithium extraction in Nevada and Jujuy create fundamentally different patterns of revenue generation and distribution. In Nevada, mining operations are subject to

[4] Schenker et al. "Is Lithium from Geothermal Brines the Sustainable Solution for Li-Ion Batteries?" *Renewable and Sustainable Energy Reviews* 199 (July 1, 2024) https://doi.org/10.1016/j.rser.2024.114456.

a tax which imposes a 5% tax on net proceeds (after deduction of certain expenses). This revenue is distributed directly to the rural counties where mining occurs and to the Nevada Department of Education fund, creating direct fiscal benefits for local communities and state education services. As a historical mining state, community support and engagement with the mining industry is deeply tied to this economic benefit.

In contrast, Jujuy's fiscal framework is characterized by minimal royalties (capped at 3% by federal law) and extensive tax incentives established through the 1993 Mining Investment Law. These incentives include tax stability provisions guaranteeing unchanging tax rates for 30 years and various deductions that significantly reduce effective payment rates. While the provincial mining agency JEMSE maintains an 8.5% ownership stake in lithium ventures, provincial officials explicitly prioritize direct foreign investment over royalty revenue. This approach has resulted in minimal direct revenue benefits for the province or local communities from the existing operations at Sales de Jujuy and Minera Exar. The royalties that are collected are consolidated by the provincial authorities, not distributed to the rural regions in which extraction is actively occurring.

The differential revenue distribution creates important implications for long-term economic sustainability. Nevada's system channels a portion of mineral wealth back to extraction communities and educational systems, potentially building human capital and infrastructure that outlasts mining operations. Due to a long history of economic prosperity from mining in the state, lithium provides an opportunity for a continuation of this legacy. Jujuy's approach, while successful at attracting foreign investment, has created limited fiscal resources for addressing mining impacts or developing economic alternatives, potentially creating greater vulnerability to eventual resource depletion or market

downturns. In addition, local communities fail to see economic benefit from extractive activities yet are faced to deal with the consequences of proximity. This is due to underlying uneven development within the province and the country of Argentina in general, where certain groups, such as the indigenous groups in Jujuy, are valued less.[5]

Value Chain Development

Perhaps the starkest contrast between the two regions lies in value chain development. Despite development narratives playing a large role in legitimizing the expansion of lithium extraction in both locations, Nevada demonstrates better capabilities to develop downstream processing and value chains.

Nevada's "lithium loop" strategy explicitly aims to develop the entire lithium value chain within the state, from extraction to processing, battery manufacturing, and recycling. This approach is supported by strategic investments, including the Tesla Gigafactory near Reno and University of Nevada research initiatives on battery technology. While still emerging, this integrated approach creates potential for capturing greater economic value within the region. Nevada's lithium industry seeks to supply for domestic demand from battery manufacturers, linking supply chains from extraction of lithium to electric vehicle manufacturing, all within the state. In Jujuy, despite rhetoric about domestic battery production and value-added processing, the reality reflects a commodity export model that hinders downstream development opportunities. Lithium carbonate produced at Sales de Jujuy and Minera Exar is primarily exported via the Angofasto port in Chile (530 km away) to supply battery production networks in China and the United States. Provincial initiatives to establish battery

[5] Barbara Göbel, "La minería del litio en la Puna de Atacama: interdependencias transregionales y disputas locales," IBEROAMERICANA Vol. 13, 135-149 Páginas. https://doi.org/10.18441/IBAM.13.2013.49.135-149.

manufacturing have largely failed to materialize beyond small pilot projects. The theoretical emphasis on domestic industrialization contrasts sharply with actual patterns of raw commodity export, in which the lithium produced in Jujuy is shipped as a raw material and produced into end-products elsewhere.

Nevada's more diversified approach—integrating extraction, processing, manufacturing, and recycling—creates potential economic benefits that could outlast the depletion of specific lithium deposits. The state's integration of lithium development with renewable energy deployment (particularly geothermal and solar) further enhances potential economic synergies and diversification. In contrast, Jujuy's model exhibits classic characteristics of resource dependency, with minimal value addition, limited revenue capture, and few linkages to other economic sectors. While the province has invested in the Cauchari Solar Park (300 MW) as a complementary renewable energy initiative, there is limited evidence of systematic economic diversification planning or post-extraction transition strategies. This enhances vulnerability for eventual resource depletion and global market fluctuations.

Critically, economic resilience is also shaped by differential capacity for technological innovation. Nevada benefits from its proximity to research universities, established mining engineering expertise, and integration with California's innovation ecosystem. Efforts to develop DLE and other advanced extraction technologies strategically position the region to adapt to changing market conditions and environmental conditions. Jujuy, despite research initiatives through the National University of Jujuy and SEGEMAR (the Argentine Mining Geological Service), exhibits more limited innovation capacity, with technological processes largely controlled by multinational corporations with minimal local knowledge transfer or incentive to do so.

This divergence creates significant implications for economic sustainability. Nevada's value chain approach potentially establishes more diverse and resilient economic activities with greater multiplier effects, while Jujuy's commodity export model remains vulnerable to global price fluctuations and offers limited opportunities for economic diversification or technology transfer. However, the true effectiveness of Nevada's development agenda remains to be seen, as interviews revealed concerns about the validity of a "lithium loop" and who would benefit.

Employment and Education

Economic sustainability is deeply tied to employment patterns, and the ability of local communities to economically benefit from nearby extractive activity. In the case of employment, Nevada lithium appears as an opportunity for rural, economically stagnant regions. In Nevada, the Silver Peak operation employs approximately 80 full-time workers, while the Thacker Pass project promises to create 300-500 jobs during construction and roughly 300 permanent positions once operational. While these positions are subject to US labor laws, including minimum wage requirements, workplace safety regulations, and benefits structures, that ensure relatively high-quality employment, issues of labor are still under dispute. When it comes to the whole value chain and the prospect of a "lithium loop," interviews revealed significant concern about the rural-urban divide, where higher paid positions for engineers and manufacturing will be consolidated in urban regions, leaving rural communities with less relative economic opportunity. This represents a continuation of core-periphery models and uneven development discussed earlier, in which these relationships are reproduced within the state. The urban

centers (core) extract from the rural natural resources (periphery), and wealth is heavily consolidated into the core.

In the Olaroz-Cauchari region of Jujuy, lithium operations provide employment to approximately 30% of the local population in the department of Susques, though exact numbers are not publicly disclosed by operating companies. These positions are predominantly in construction, security, and basic operations rather than technical or managerial roles, which are often filled by workers from outside the region. Wage data is not publicly available, though Argentina's general mining sector offers wages above the national average but below those in comparable positions in developed economies. This illuminates an issue with foreign investment in Argentina and the limitations of raw material export. Higher paying jobs are held by professionals employed by the foreign company, and later economic benefit from manufacturing or processing jobs is consolidated in regions like China where batteries, EVs and other goods are produced and sold.

A critical difference emerges regarding skill development and knowledge transfer. Nevada's "lithium loop" concept specifically includes workforce development programs through community colleges and universities to train local workers for various aspects of the lithium value chain. Part of the "lithium loop" agenda includes billions of dollars in grants to Nevada universities to improve technology departments and facilities.

In Jujuy, despite provincial rhetoric about developing domestic lithium industries, there is limited evidence of systematic skills development programs that would enable local workers to advance into higher-skilled positions within the industry. The employment dimension reflects important sustainability implications. Nevada's approach potentially creates more durable human capital through

skills development that could outlast specific mining operations, while Jujuy's pattern creates more dependency relationships with limited pathways for advancement or transferable skill development. In addition to economic sustainability, local employment and benefits can create social sustainability and acceptance of mining activity.

These patterns suggest that Nevada's approach, while imperfect, creates conditions more conducive to long-term economic sustainability beyond the extraction phase, while Jujuy's model risks creating classic boom-bust dynamics associated with resource dependency unless significant policy shifts occur to enhance value capture, knowledge transfer, and economic diversification.

Social Sustainability

Social sustainability relates to how community members engage with and either legitimize or de-legitimize extractive activity. Social sustainability requires the fair distribution of resources and opportunities, and the inclusion of communities. In the extraction realm, it requires that the extractive industry does not devalue and dispossess some groups in the pursuit of development. This approach is informed by the local civic epistemologies, meaning "the stylized, culturally specific ways in which publics expect the state's expertise, knowledge, and reasoning to be produced, tested, and put to use in decision-making."[6]

[6] Jasanoff, Sheila. Designs on Nature: Science and Democracy in Europe and the United States. Princeton: Princeton University Press, 2011.

Community Engagement and Consultation Processes

The processes for local community engagement exist in both cases, yet the efficacy of these systems remains unclear. In terms of structure, both Jujuy and Nevada have a step in the permitting process which requires community engagement.

In Jujuy, lithium projects must undergo the UGAMP (Unit of Mining Environmental Management) review process, part of which requires meetings where indigenous leaders, water commission representatives, and other stakeholders evaluate mining company presentations. This process theoretically provides a 60-day window for raising objections, but first the UGAMP meeting must receive signed documentation of approval from local community assemblies. This process appears to slow development projects in some regions in Jujuy where indigenous resistance has organized against lithium mining, such as in Salina Grandes. However, there is a lack of transparency within governmental structures about community pathways for resistance to mining activity, where for some, such as those in the Olaroz-Cauchari water basin, there is a perceived lack of agency when it comes to stopping or limiting the expansion of mining activity.

In Nevada, consultation follows the National Environmental Policy Act (NEPA) framework, which requires public meetings, comment periods, and formal responses to concerns. The Thacker Pass project's approval process occurred during the COVID-19 pandemic in 2020, which significantly limited in-person participation from the Fort McDermitt Paiute and Shoshone Tribe and other stakeholders. Interviews revealed that the lack of community input and engagement with the project is the primary reason for protest, because prospecting and development began to occur on ancient burial sites reflecting a failure of the consultation process. Thacker Pass is a glaring example of Nevada's social

sustainability failures, as Thacker Pass was hurried through the NEPA process. In this case, it was completed it in under one year rather than the typical 3-5 years for projects of similar complexity. This expedited project has been criticized for curtailing meaningful consultation, particularly with indigenous communities, and raised concerns about Thacker Pass becoming a role model for future lithium development in Nevada.

Both systems exhibit structural limitations that potentially undermine long-term social sustainability. Jujuy's requirement for pre-approval creates potential for coercive or divisive practices, while Nevada's accelerated NEPA implementation during the pandemic circumvented meaningful dialogue at critical junctures. These consultation shortcomings potentially create ongoing legitimacy deficits that could manifest in future conflicts.

Benefit Distribution and Local Development

A main concern that emerges with extractive activity is the distribution of benefits to local communities, as sites of extraction become "sacrifice zones" while wealth is consolidated in urban centers and overseas. This pattern is prevalent in both Nevada and Jujuy lithium contexts, as lithium extraction occurs in rural regions, without much benefit for the surrounding communities.

In Jujuy, economic benefits are unevenly distributed, aligning with historical extractivist dynamics. In the northwestern part of the province, despite expanding lithium, the department of Susques still must deal with limited infrastructure improvements, and a lack of community development initiatives. The province's rejection of substantial mining royalties in favor of direct foreign investment has constrained resources available for community investment, while minimal tax

revenue limits public service improvements. This part of the province continues to exist without support, oversight or infrastructure from the state. This is mismatched with the economic prosperity that this region brings to Jujuy province and Argentina nationally. This region is home to two of the largest lithium mines in the country, making Argentina a global leader in lithium markets, yet none of that prosperity is shared by the people of Susques or the surrounding communities. Instead, this region faces extreme barriers to development and economic prosperity while being deprived of vital water resources and overlooked by the government.

In Nevada, the system of mineral taxation creates more direct fiscal benefits for local counties, funding infrastructure, education, and services independent of corporate social responsibility initiatives. However, interviews revealed similar patterns in Nevada of rural communities facing environmental and economic challenges while urban areas experience growth and higher wages, benefiting more from the "lithium loop" concept than those located near extraction. In regions like Esmeralda County, where Silver Peak mine operates, it is an extremely sparsely populated region where the local government lacks resources and/or budget to properly review projects and the ability to participate fully in the NEPA process. As such, proper community engagement is more difficult in under-funded and rural regions. The Thacker Pass project has established a negotiation culture with communities in Humboldt County, attempting to pacify local discontent including specific investments in educational programs and community infrastructure. Implementation is just beginning, but interviews raised concerns about the truth behind these promises. Many of these operations promised significant local employment, such as Thacker Pass, however, work camps have been appearing nearby to both Thacker Pass and Rhyolite ridge, indicating that these projects are bringing in labor from other places. Across rural regions of

Nevada, interviewees also noted that many Nevadans are not interested in working on mining projects, and so, there is no benefit to having this activity nearby.

Indigenous Relationships and Territorial Rights

Indigenous relationships with mining represent a critical dimension of social sustainability in both regions. In Jujuy, the department of Susques has a predominantly indigenous population, including Kolla and Atacameño peoples with historical claims to territorial rights that predate modern mining operations. The Argentine Constitution (reformed in 1994) and ILO Convention 169 theoretically recognize indigenous rights to consultation and territorial autonomy, but implementation remains partial and contested. Additionally, despite this territorial autonomy, Jujuy's pro-mining regulations frequently dispossess the land.

The relative acceptance of lithium operations in the Olaroz-Cauchari region contrasts sharply with resistance in Salinas Grandes, where indigenous communities have actively opposed exploration. This difference appears connected to historical experiences; communities in Susques have longer histories of engagement with mining activity and viewed lithium as an economic opportunity following the closure of previous mining operations that had employed local residents. In Nevada, indigenous relationships center primarily on the Fort McDermitt Paiute and Shoshone Tribe near the Thacker Pass project. Some tribal members participating in protest actions while others support potential economic opportunities. Conflicts emerged regarding claims that Thacker Pass contains burial sites and holds cultural significance, though these claims were not fully adjudicated before project approval. The rushed NEPA process during COVID-19 pandemic restrictions limited meaningful tribal consultation.

Indigenous land disputes in both regions reveal a condition of peripherality that emerges amidst extraction.

In both regions, provincial/state and federal governance creates complex jurisdictional challenges for indigenous communities seeking to assert territorial rights. However, a significant difference emerged in 2023 when Jujuy's provincial government implemented constitutional reforms that critics argue were designed to limit protest and facilitate access to indigenous lands for mining companies. These reforms sparked widespread protests and escalated rather than diminished tensions over indigenous rights in the province. These divergent trajectories suggest that while both regions face indigenous relations challenges, Jujuy's recent shift toward more restrictive governance potentially creates greater long-term social sustainability risks by undermining consultation mechanisms and territorial rights that are essential for maintaining social license.

Social License to Operate

The cumulative effect of these social dimensions manifest in different patterns of social license to operate—the ongoing acceptance of mining operations by local communities and broader stakeholders. In the Olaroz-Cauchari region of Jujuy, operations have maintained a degree of social acceptance. This conditional acceptance appears increasingly fragile, however, as environmental impacts accumulate, particularly water scarcity affecting traditional pastoral livelihoods. The provincial government's 2023 constitutional reforms limiting protest rights suggest recognition that social acceptance may be eroding, with authorities responding through restrictive measures rather than addressing underlying concerns about benefit distribution and environmental impacts. This limiting of

protest movements against mining activity in the region has potential to significantly limit the social sustainability of mining ventures. Social license has the power to promote or inhibit the success of mining activities, especially as regulatory and political pathways to resistance are increasingly limited by the Jujuy government.

In Nevada, social license remains contested but operates within a more established framework of mining governance. Opposition to Thacker Pass has included legal challenges, protest encampments, and advocacy campaigns, but it primarily channels through institutional mechanisms rather than direct confrontation. The NEPA process, despite limitations in implementation, provides structured opportunities for opposition groups to register concerns and potentially influence operations. In addition, multiple conservation and environmental justice groups in Nevada have sought litigation against mining companies to protect land that is important to community members, water resources and endangered species. Local governance in Nevada is increasingly involved in these disputes, especially when opposition to mining or exploration in a region receives bipartisan support. There are concerns that the state-wide agenda pushing for a "lithium loop" could undermine local concerns about where extraction occurs and who benefits. Additionally, residents of Reno and Carson City are concerned about how an expanding technology industry could increase the cost of living in urban centers.

Nevada's system provides multiple institutional channels—including courts, regulatory agencies, and elected officials—for addressing grievances, potentially allowing incremental adjustments that maintain minimal social acceptance. Jujuy's approach increasingly relies on restricting opposition rather than addressing underlying concerns, potentially creating conditions for more significant future conflicts that could threaten operational continuity. These patterns suggest that while both regions face

social sustainability challenges, Nevada's institutional framework provides more robust mechanisms for maintaining minimal social acceptance over time, while Jujuy's increasing reliance on restrictive governance rather than benefit redistribution or environmental protection creates growing risks to long-term social license.

Results and Findings

This comparative analysis of lithium extraction in Nevada and Jujuy reveals how different governance structures, historical contexts, and power dynamics produce divergent sustainability outcomes across environmental, economic, and social dimensions.

Nevada's approach to lithium extraction, though imperfect, demonstrates relatively stronger sustainability potential through several key mechanisms: strict water governance that drives technological innovation; fiscal structures that distribute benefits to local communities; multi-stakeholder engagement processes with institutional channels for contestation; and deliberate value chain development that could potentially outlast resource depletion. Despite significant shortcomings, particularly in indigenous consultation and rural-urban equity, Nevada's model provides structural conditions that better facilitate long-term viability. This may be, in part, due to the infancy of the lithium industry relative to other producers worldwide, and because Nevada is supplying domestic demand for lithium with relatively low rates of foreign investment.

In contrast, Jujuy's provincial-led model prioritizes foreign investment, with limited regulatory oversight, creating conditions that undermine long-term sustainability. The province's approach exhibits concerning characteristics: weak environmental protections that enable water-intensive

extraction methods without adequate monitoring; minimal royalty capture that constrains public investment and increasingly restrictive governance that limits rather than addresses community concerns. While lithium operations have achieved conditional acceptance in some communities, the province's recent turn toward restricting protest rights rather than addressing underlying concerns suggests eroding social license between mining corporations and communities.

Table 5.2— Summary of findings

	Nevada, USA	Jujuy, Argentina	Results/Findings
Environmental Sustainability	Strict water governance and permitting Water saving technology (DLE) Legal and regulatory pathways for addressing ecological concerns but outdated regulation Renewable energy source implementation (geothermal, solar, etc) to power projects	Pro-mining water governance and permitting Brine-evaporative projects limited legal pathways within the province for contestation, disconnect between provincial priorities and scientific/community concerns renewable energy investment and national natural gas use to power projects	Nevada exemplifies regulatory structures that more effectively navigate environmental concerns around water and ecological protection, and more advanced investment in solar/geothermal projects. Due to the divergence in regulatory oversight from state/provincial authority between the two cases, Nevada has potential for better sustainability outcomes environmentally.
Economic Sustainability	Mining royalties (5% or more) distributed to state education funds and individual mining counties	Mining royalties capped at 3%, consolidated to province, not individual departments	Nevada has significant investment in upstream production abilities due to "lithium loop" agenda setting, and local frontline communities benefit from

	Value chain development and "lithium loop" to extraction, produce and manufacture lithium end-products within Nevada Employment of local communities remains contested and understudied as new firms come online Partnerships with local universities encourage local innovations to technology and provide grant funding for universities	Development agenda present in Jujuy government agenda but lacks incentivization and forward linkage development, raw materials exported out of Argentina Local employment is limited to construction/maintenance with higher paying jobs held by foreign workers Limited funding for universities in Jujuy province, apparent need for local innovation and technological expertise	fiscal mining tax structure in Nevada vs. little to no local benefit in Jujuy. The long-term economic sustainability of these two cases remains to be seen, however Nevada has seen vast development of value chains and educational benefits compared to Jujuy.
Social Sustainability	NEPA process requires community consultation (questionable) Concerns about benefits being consolidated to urban areas while rural areas contend with consequences Indigenous concern about being disregarded in permitting/exploration process at Thacker Pass	UGAMP review process requires community consultation (more effective in some regions than others) "vacuum of state" with increased oppression of protest, indicating unrest and lack of social acceptance Protest limited by reforms	Ultimately, Nevada seeks a "social license to operate" with certain groups, while disregarding that same right for others (i.e. indigenous groups as exemplified at Thacker Pass). However, Jujuy's repressive reforms to limit protest and disregard of frontline communities presents obstacles to social sustainability and the long-term viability of lithium operations.

These findings challenge simplistic sustainability narratives by demonstrating how political-economic structures fundamentally shape environmental outcomes, economic benefits, and social dynamics. The comparative analysis reveals that sustainability is not merely a technical question of extraction methods but a geo-political one about resource governance, benefit distribution, and knowledge valuation in decision-making.

As global lithium demand accelerates, Nevada's emergence as a producer offers potential pathways for more sustainable extraction relative to established patterns in Jujuy. Realizing this potential requires strengthening consultation processes, ensuring equitable benefit distribution beyond urban centers, and maintaining regulatory frameworks that incentivize environmental improvement. The comparison demonstrates that institutional structures, benefit mechanisms, and channels for contestation determine whether extraction produces long-term viability or perpetuates boom-bust resource dependency.

Locating extraction sites near end-use-product production does improve sustainability outcomes. Both regions' sustainability trajectories remain in flux, with Nevada's industry still emerging and Jujuy's approach evolving in response to various pressures. This comparative analysis provides critical insights into the political-ecological conditions that either support or undermine sustainable lithium extraction in arid regions. The final chapter looks toward the future of lithium to suggest avenues for research and investment.

CHAPTER SIX: LOCATING SUSTAINABLE EXTRACTION

> We don't make reality. We evade it. By looting natural capital and hiding the costs. But the bill is coming, and we won't be able to pay.
>
> — Richard Powers, *The Overstory*[1]

Introduction

Extraction is not a remnant of industry past but rather fueling the future. As the material requirements of the "green" energy transition increase demand for key minerals and expand extractive frontiers, we risk perpetuating unsustainable systems of extraction that this energy transition seeks to resolve. A global sustainability transition relies upon extractive activity expanding to new geographies, ecosystems and communities. This thesis explored the complex puzzle between extractive activity and sustainability and claims that sourcing from new frontiers and locales may improve sustainability outcomes of extraction. It began with the question: To what extent does the locale of extraction impact sustainability? More specifically, to what extent do dynamics of extraction change when a commodity is extracted in the same locale where it is consumed?

In our globalized world, consumers remain disconnected from the raw materials used to create finished products, unaware of the localized impacts on communities, ecologies, and economies. The findings of this study suggest that sustainability outcomes improve when extraction occurs in proximity to production and manufacturing, and when planning integrates these processes. New extractive

[1] Richard Powers, *The Overstory*, First edition (New York: W. W. Norton & Company, 2018).

frontiers, rather than simply expanding environmental burdens, can serve as laboratories for local innovation with global implications, helping to resolve the paradox of requiring more minerals to build a less extractive future.

Locale of Extraction and Sustainability: The Empirical Evidence

The Comparative Case: Nevada and Jujuy

This comparative case study of extractive frontiers, using Nevada and Jujuy, provides a powerful lens for understanding the impact of locale on sustainability outcomes in extractive contexts. These cases are particularly useful for several reasons. First, they represent contrasting contexts of extraction relative to consumption: Nevada lithium serves primarily domestic markets within the United States, while Jujuy's lithium is exported to global markets. Second, both regions are actively expanding lithium production within similar timeframes (2015-2025), allowing for contemporary comparison rather than historical retrospective. Third, both regions employ "green developmentalism" narratives to legitimize extraction, yet operationalize these concepts differently, creating a natural experiment in how sustainability is interpreted and implemented across contexts. These cases allow insight into the key differences that either promote or inhibit long-term sustainability in extractive industry.

This case comparison has theoretical utility as it explores extraction beyond the binary global North-South distinctions that dominate extractivist literature.[2] By examining how extraction dynamics

[2] Christopher Chagnon et al., "From Extractivism to Global Extractivism: The Evolution of an Organizing Concept," *Journal of Peasant Studies* 49 (May 9, 2022), https://doi.org/10.1080/03066150.2022.2069015; Gavin Bridge, "Global Production Networks and the Extractive Sector: Governing Resource-Based Development," *Journal of Economic*

manifest in both a traditionally "peripheral" context (Jujuy) and a historically "core" economy (Nevada), the study demonstrates that core-periphery[3] dynamics can exist within national boundaries, creating uneven development across nations, within nations, and regions.

As lithium is the mineral with the fastest growing demand, geographically abundant resources, and direct connection to decarbonization technologies, lithium represents the archetype of a transition mineral whose extraction dynamics will shape the sustainability of the green energy transition. It is geographically abundant, meaning it provides a valuable avenue through which to explore how an extraction locale impacts sustainability outcomes.

Sustainability Outcomes and Key Findings within the Case

There are several key findings from this case study about sustainability outcomes in each locale. Sustainability is evaluated through a focused comparison of metrics within the three-pillar framework: environmental, economic and social.

Firstly, this study advises that Nevada exhibits potential for greater environmental sustainability outcomes when compared to Jujuy. Differences between the two cases' usage and governance was the

Geography 8, no. 3 (May 1, 2008): 389–419, https://doi.org/10.1093/jeg/lbn009; Facundo Martín, "Reimagining Extractivism: Insights from Spatial Theory," in *Contested Extractivism, Society and the State*, ed. Bettina Engels and Kristina Dietz (London: Palgrave Macmillan UK, 2017), 21–44, https://doi.org/10.1057/978-1-137-58811-1_2.

[3] Cilja Harders, "Provincializing and Localizing Core-Periphery Relations," *Middle East - Topics & Arguments* 5 (November 3, 2015): 36–45, https://doi.org/10.17192/meta.2015.5.3790; Fernando Henrique Cardoso, "The Consumption of Dependency Theory in the United States," *Latin American Research Review* 12, no. 3 (1977): 7–24, https://doi.org/10.1017/S0023879100030430; Ulrich Brand and Markus Wissen, "Crisis and Continuity of Capitalist Society-Nature Relationships: The Imperial Mode of Living and the Limits to Environmental Governance," *Review of International Political Economy* 20, no. 4 (August 1, 2013): 687–711, https://doi.org/10.1080/09692290.2012.691077.

most significant factor that contributed to environmental outcomes between cases. Other factors that were considered still remain to be seen, as both cases look to utilize renewable energy resources to power extraction and are currently implementing these technologies. Additionally, the permitting process for mining activity in both regions is imperfect. There are limitations to the validity of the finding that Nevada lithium extraction is more environmentally sustainable than Jujuy. Primarily, due to the infancy of Nevada's lithium landscape when compared to Jujuy, and the difference between extraction methods between cases. However, water permitting in Nevada has made brine-evaporative lithium projects unfeasible due to their water and land use requirements, whereas in Jujuy, these operations are still expanding. Additionally, reporting frameworks for water usage, environmental impact assessment and processes across cases differed, complicating objective comparison.

Secondly, the findings suggest that Nevada's approach to lithium extraction may be more economically sustainable in the long-term when compared to Jujuy. Economic sustainability outcomes relied upon a variety of factors, but most importantly, by analyzing value chain development and fiscal structures across cases. Nevada's "lithium loop" strategy explicitly aims to develop the entire supply chain within the state, from extraction to battery manufacturing and recycling, and while implementation remains nascent, this approach creates potential for greater economic resilience and development in the region. While both regions have a pro-mining fiscal policy, in Nevada, there is financial benefit provided through regulatory structures for rural communities located near mining activity, and statewide. In contrast, Jujuy's lower tax rate reflects how the province's commitment to attracting private foreign investment overlooks rural and indigenous communities close to mining

activity. Further implications of this finding are limited in this study, as a more in-depth investigation into difference between fiscal structures is required.

Third, social sustainability outcomes may improve in the Nevada context when compared to Jujuy, however both cases revealed troubling patterns of social inequality and disregard of certain communities. The community consultation processes for permitting lithium extraction projects in both regions demonstrate structural limitations. Key differences do emerge beyond the permitting process as Nevada's regulatory framework provides multiple avenues for concerns to be addressed through litigation, conservation group intervention, and multi-stakeholder engagement. While implementation is imperfect and has significant challenges, these mechanisms create accountability structures largely absent in Jujuy, where the provincial government mainly prioritizes the interests of foreign investment. In both locations, it appears that there is a "social license to operate"[4] from the neighboring communities, but this remains in flux due to capacity for negotiation and consultation moving forward. Due to this study's limitations that prevented fieldwork in either locale, these conclusions and findings may not be widely applicable across these contexts. Key informant interviews primarily engaged with regulators, environmental advocates and activists, indigenous leaders and academics, creating a gap in the research for public opinion. This limitation was partially mitigated through secondary source triangulation. This finding has limitations for future applicability, as new dynamics unfold under the Trump

[4] John R. Owen and Deanna Kemp, "Social Licence and Mining: A Critical Perspective," *Resources Policy* 38, no. 1 (March 2013): 29–35, https://doi.org/10.1016/j.resourpol.2012.06.016.

administration in the Nevada context and the effects of Jujuy's 2023 constitutional reforms that limited pathways of contestation unfold.

Conclusions and Implications for Nevada, Jujuy, and Lithium

The findings from this comparative analysis led to several important conclusions regarding the locale and sustainability in lithium extraction for these specific cases and for lithium extraction globally. First, and most importantly, these findings may suggest that locale of lithium extraction and production sites does have implications for sustainability outcomes. Proximity between extraction sites and end consumption markets may create conditions more conducive to sustainability across environmental, economic, and social dimensions. When lithium is extracted in regions that also manufacture and consume the end products (as in Nevada's evolving model), there seem be stronger incentives for environmental stewardship, economic diversification, and social engagement, enacted through regulatory frameworks This provides further empirical grounding for political ecology frameworks that argue sustainability is challenged by a dislocation of extraction, production and end-consumption.

Secondly, this study suggests that extraction can become more sustainable when located in stricter regulatory environments. Regulatory frameworks seem to significantly influence how extraction dynamics manifest, and strong regulation may indicate greater agency to set standards for new industries such as lithium, that promote sustainability. Nevada's strong regulatory frameworks surrounding water usage, permitting and fiscal policy existed due to Nevada's legacy of metal mining that preceded lithium. In contrast, for Jujuy, extractivist logics that prioritize foreign investment frame their regulatory policies

and approach, resulting in less-sustainable outcomes in all three pillars. This suggests that Jujuy could address institutional structures to mitigate negative externalities of extraction locally.

Third, these findings suggest that to truly develop a sustainable lithium supply chain, it is not sufficient to attach a "green" identity to lithium solely because of its end-use in carbon-reducing technologies like renewable energy or electric vehicles. In Jujuy, while "green" development of production and manufacturing facilities face barriers, opportunities arise for "upstream" green development which could occur through innovations in extraction processes that decrease costs, land-use and water-use, making Jujuy a world leader in lithium extraction.

These conclusions have direct implications for the future of lithium extraction in both regions. For Jujuy, the findings suggest that continued reliance on water-intensive methods, minimal local benefit distribution, and restricted community engagement threaten long-term viability as social and environmental costs accumulate. In Jujuy, colonial legacies, stark inequality within the province and the country at large, and solidified export markets for raw materials create barriers for regulatory reform and shifting their role in the global lithium economy. For Nevada, the infancy of the lithium industry provides promising pathways towards sustainable extraction, dependent on the state maintaining robust regulatory frameworks, ensuring equitable benefit distribution beyond urban centers, and strengthening rather than circumventing consultation processes.

Beyond the Cases

Theoretical Implications

Firstly, this study reinforces traditional notions of extractivism, adding complexity to the empirical grounding of the theory, and tests the applicability in modern markets. The findings are aligned with the claim that extractivism (characterized by export of raw materials) is ecologically unsustainable,[5] or at least less sustainable than extraction in contexts without extractivist dynamics. These dynamics are characterized by export-oriented raw commodity extraction that places value on attracting foreign investments and maintaining competitive prices globally, creating sustainability concerns on local levels. These claims are further substantiated by the findings of this study, as extraction that provides domestic markets was able to more effectively acknowledge and operate within the ecological limitations of the environment due to regulation and added incentive to do so.

Secondly, this study supports Bridge's argument[6] that the theory of core-periphery dynamics exists beyond traditional global North-South divides. Evidence suggests that peripheries exist within "core" countries themselves. In Nevada, lithium extraction occurs in rural areas while economic benefits concentrate in urban centers, creating internal core-periphery relationships. This pattern shows how historically marginalized groups (economically disadvantaged rural communities and indigenous populations) are disproportionately subjected to dispossession due to resource extraction even within

[5] Chagnon et al., "From Extractivism to Global Extractivism."

[6] Bridge, "Global Production Networks and the Extractive Sector."

wealthy nations, along the line of the theory of uneven development.[7] However, the study adds an important qualification: while peripheries exist within core countries, these "internal peripheries" experience better conditions than peripheries in developing nations. When comparing extraction sites across the global North-South divide, the research found that extraction in core countries produced better social and economic sustainability outcomes than extraction in peripheral countries. In essence, the findings confirm Bridge's assertion that peripheries exist beyond the simple North-South dichotomy, but add that exploitation is less severe for peripheral regions within wealthy core countries than for regions in traditional peripheral countries.

Thirdly, my findings offer important empirical insights into a theoretical nexus proposed by author Riofrancos,[8] termed the "security-sustainability nexus," described as "an interlocking set of policies and justifications that promote lithium extraction and emphasize the environmental credentials of global North mining." My comparative analysis provides concrete evidence of how this theoretical concept manifests in practice, as exhibited in the Nevada case, while investigating the less-developed "sustainability" aspect of Riofrancos argument. However, my findings add critical nuance, addressing concerns that the onshoring movement would not result in improved sustainable extraction but create internal peripheries, as discussed above. The findings of my study imply that new extractive frontiers created through the "onshoring" do have the capability to improve the sustainability of extraction and innovate methods. This study strongly suggests that proximity between extraction and consumption,

[7] Smith, *Uneven Development: Nature, Culture, and the Production of Space*, Oxford: Blackwell, 1984.

[8] Thea Riofrancos, "The Security–Sustainability Nexus: Lithium Onshoring in the Global North," *Global Environmental Politics* 23, no. 1 (2023): 20–41.

central to the "onshoring" movement, does create some opportunities for greater sustainability through integrated value chains and regulatory oversight, especially when extraction emerges under a sustainability imperative.

Methodological Implications

The findings of this study made contributions to the methodological approach of evaluating sustainability. This study has implications for sustainable extraction studies, demonstrating that sustainability in extractive contexts cannot be reduced to technical efficiency metrics but must account for governance structures, benefit distribution mechanisms, and social acceptance. By approaching and measuring sustainability through both quantitative data and qualitative data, and through three pillars that compose it, this study adds a holistic method through which we can evaluate sustainability. By documenting how similar extraction technologies produce different sustainability outcomes depending on regulatory contexts and power relations, the study advances conceptual frameworks for evaluating extraction sustainability. Additionally, the study's focus on forward-looking sustainability assessment—examining factors that influence the long-term viability of operations rather than just current impacts—offers a methodological approach that better aligns with sustainability's inherently future oriented nature. This future-oriented approach is often underemphasized in extractive industry analyses that focus on immediate impacts rather than long-term trajectories. Yet, this type of assessment could help to ensure the long-term viability of extraction sites. This element is essential to ensuring that new frontiers, ecologies and communities are not sacrificed as extractive zones and abandoned due to sustainability assessment failures.

Policy Implications

The findings carry significant policy implications for transition mineral governance as the energy transition accelerates and global leaders look to supply sustainably sourced minerals. First, the comparative analysis suggests that policies encouraging domestic sourcing of transition minerals within consuming countries may produce better sustainability outcomes than relying exclusively on global supply chains from traditional peripheral regions. This has implications for "friend-shoring," "near-shoring" and "onshoring" policies being pursued by the United States, the European Union, and others seeking to secure critical mineral supplies.

Second, the empirical analysis highlights the importance of robust governance in determining the sustainability of lithium operations, and potentially all mining ventures. As policymakers consider expanding lithium production, developing specific regulatory frameworks that account for the unique characteristics of lithium extraction becomes essential, particularly in arid or biodiverse regions where multiple users compete for limited water resources. This study demonstrates that strict regulation and governance does not entirely inhibit extractive activity but rather requires innovation and evolution within ecological boundaries.

Third, the study underscores the need for policies that ensure that economic benefits from transition mineral extraction reach local communities rather than remaining concentrated in urban centers or with foreign investors. Nevada's model of distributing mining taxes directly to counties where extraction occurs provides a potential template for more equitable benefit sharing that could reduce opposition to mining and improve economic circumstances for resource-rich regions of the world.

Fourth, the findings demonstrate that effective consultation mechanisms and social license to operate are not merely ethical considerations but fundamental determinants of operational viability. Policies that strengthen rather than circumvent meaningful consultation with affected communities, particularly indigenous groups, are essential for sustainable extraction.

Fifth, the comparative analysis suggests that policies encouraging integrated supply chain development (extraction, processing, manufacturing) within a region may produce better sustainability outcomes than policies focused solely on extraction efficiency. This has implications for industrial policy approaches to the energy transition that have thus far often separated extraction governance from manufacturing policy and increasingly lengthened global supply chains.

Mining the Future: Research Horizons and Imperatives

While this study provides valuable background for studies on sustainable extraction, future research is required to ensure a future of sustainably sourced minerals. Firstly, within this case, further research could include longitudinal studies tracking how extraction dynamics evolve over time in both Nevada and Jujuy. This would provide valuable insights into whether initial differences in sustainability trajectories persist or converge. As Nevada's lithium industry matures and Jujuy potentially reforms its governance approach, comparative analysis over a longer timeframe would enhance understanding of how locale influences long-term sustainability. This would allow many of the dynamics recorded in the thesis to have temporal viability over a longer period.

Secondly, this comparative framework could be expanded to include additional lithium producing regions with varying relationships between extraction and consumption, which would test the generalizability of this study's findings. Examining cases such as Portugal (extracting for European consumption), Australia (extracting primarily for export), and Chile (established producer with evolving governance) would provide a more comprehensive picture of how locale influences extraction dynamics globally. This would also provide further empirical validity, as a multi-sited investigation could test the impact of variables such as colonial legacy, regulation, proximity of production to extraction on sustainable outcomes.

Thirdly, there is a need for research that investigates how technological innovations like direct lithium extraction (DLE) develop and diffuse across different extraction contexts. This information would enhance our understanding of how technical solutions interact with governance structures to shape sustainability outcomes and contribute to the field of science-technology studies. As DLE technologies mature, comparative analysis of their implementation and impacts across diverse regulatory environments would be particularly valuable. Additionally, this nascent technology could have vast applications for providing for lithium markets without expanding the geographies in which extraction occurs. These avenues are currently under-development, as firms look to extract lithium from "produced water" generated from oil drillings[9] and from geothermal brines[10] already used to generate

[9] Amit Kumar et al., "Lithium Recovery from Oil and Gas Produced Water: A Need for a Growing Energy Industry," ACS Energy Letters 4, no. 6 (June 14, 2019): 1471–74, https://doi.org/10.1021/acsenergylett.9b00779.

[10] Vanessa Schenker et al. "Is Lithium from Geothermal Brines the Sustainable Solution for Li-Ion Batteries?" *Renewable and Sustainable Energy Reviews* 199 (July 1, 2024) https://doi.org/10.1016/j.rser.2024.114456.

renewable energy. This could have vast impacts on the sustainability of lithium and its ecological impacts, if these processes were further incentivized.

Along these lines, I suggest a fourth avenue for future research, where lithium demand could be met without creating more "sacrifice zones." There is a need for more research on the validity and implementation of circular economies for lithium[11] such as: recycling, urban mining, and material substitution. As lithium batteries reach end-of-life in growing numbers, research on closed-loop systems could identify pathways to meet demand while minimizing new extraction. It would advance the purpose of this thesis, by meeting demand for lithium though sustainable methods beyond increased extraction.

Fifthly, there is an opportunity to reduce lithium demand globally, by mitigating the demand side for lithium-ion batteries. This could be achieved through additional research into suitable mineral substitutes for batteries, such as sodium.[12] Additionally, overall demand projections for battery requirements could shift based on policy shifts away from incentivizing more consumption of individual EVs and instead focus on modernizing public transport systems and urban planning to prioritize less energy intensive forms of transport.[13]

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[11] Laura Vega Garcia et al., "Lithium in a Sustainable Circular Economy: A Comprehensive Review," *Processes* 11, no. 2 (January 30, 2023): 418, https://doi.org/10.3390/pr11020418.

[12] Heather Hall, "Next-Generation Battery Technologies: Finding Sustainable Alternatives to Lithium-Ion Batteries," Research & Development World, November 11, 2024, https://www.rdworldonline.com/finding-sustainable-alternatives-to-lithium-ion-batteries/.

[13] Gunther Martin et al., "Lithium Market Research – Global Supply, Future Demand and Price Development," *Energy Storage Materials* 6 (January 1, 2017): 171–79, https://doi.org/10.1016/j.ensm.2016.11.004.

Within the existing literature on energy transitions and the geographies that sustain them, while marginalized groups bear the costs and experiences, there is an absence of these voices and epistemologies within this field of study. This thesis briefly touched upon the outsized impact of transition mineral extraction on indigenous and marginalized groups, yet there are barriers to the inclusion of these demographics within academic, corporate and policy realms. Future research should include and highlight indigenous and marginalized voices and scholars. It is imperative that this research looks to frame these communities and individuals not just as victims of extractive industry, or as "ecologically noble"[14] saviors, but rather to shed light upon alternative approaches and epistemologies. Dominant development and sustainability paradigms would benefit from incorporating these perspectives, challenging our accepted notions of what development means and the destructive ways in which capitalist imperatives demand we view the natural world.

By focusing on where extraction occurs, this thesis looked to parse through the abstract notions of green development and the allure of green technologies, focusing on the materials and spaces that must fuel this "green" transition. If the world wishes for a more sustainable future, we must interrogate, evaluate, and reconsider which geographies, communities and ecologies will bear the costs.

[14] Kent Redford, "The Ecologically Noble Savage." *Orion* 9 (January 1, 1991).

AFTERWORD

The world has changed drastically since I first embarked on writing this thesis nearly one year ago. Foreign policy under the Biden administration aligned with UN Sustainable Development Goals and global decarbonization, as evidenced by the Inflation Reduction Act and promotion of renewable energy investment during his term. Under the Trump administration, these alignments have shifted significantly, leaving uncertainty about how lithium and other transition mineral markets will develop, both domestically and internationally.

Amidst the current administration's pivot away from international cooperation and its focus on domestic trade priorities, we are experiencing a geopolitical restructuring that will undoubtedly impact all commodity markets and supply chains. Despite these shifts, academic and corporate entities agree that demand for transition minerals will persist, regardless of market fluctuations and price volatility. As Elon Musk, owner of leading EV company, Tesla, assumes the role of a senior advisor within the Trump administration, it seems lithium and other transition minerals could remain strategically important domestically, even as the domestic policy focus shifts away from decarbonization. Additionally, other nations in the EU and abroad continue to pursue decarbonization and incentivize the ethical sourcing of transition minerals, meaning the sustainable extraction imperative continues to persist.

As the new US administration introduces tariffs, proposed as a move to strengthen domestic manufacturing and reduce import dependency, the central question this thesis examines has become even more critical. We are entering uncharted territory, and this research can serve as a valuable roadmap for decision-makers determining how and where to source essential materials for the technologies of the future. Despite current US politics, the world has not lost sight of the future, and communities at the frontlines of extraction and climate change continue to innovate, evolve and resist the demands of the "capitalist world-eater."[1]

[1]Alexander Dunlap and Jostein Jakobsen, The Violent Technologies of Extraction: Political Ecology, Critical Agrarian Studies and the Capitalist Worldeater (Cham: Springer International Publishing, 2020), https://doi.org/10.1007/978-3-030-26852-7.

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