Analyzing the Socio-Technical Sustainability of Lithium Mining on Local Communities in the Lithium Triangle

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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As a society, we have realized that we must reduce the impact we have on our planet. Through the release of carbon and subsequent global warming, in a few centuries the Earth may be uninhabitable. For example, in 2021, global carbon emissions were 37.12 billion metric tons, an increase of almost 60% from 1990 (*Annual CO2 Emissions Worldwide 1940-2021*, n.d.). To combat global warming, scientists have started turning towards developing green technologies, with lower carbon emissions. One such technology is rechargeable batteries, which use more cleanly generated energy in the form of stored electricity. Rechargeable batteries like these are used in a plethora of applications, such as phones, laptops, and hybrid electric cars and aircraft. Lithium is a crucial component of such batteries, and so demand for lithium has skyrocketed, to 292,000 metric tons in 2020 (*Lithium Demand Worldwide by Application 2020-2030*, n.d.).

This demand has led to extensive lithium extraction in lithium rich regions. One such region is the so-called "Lithium Triangle" of South America. Made up of parts of Argentina, Chile, and Bolivia, this lithium rich region has become the focus of transnational corporations. These transnational corporations negotiate with provincial governments and local populations to establish mining rights. However, this negotiation is far from equal. Often, the demands of the local populations are downplayed or even ignored in negotiations. Also, the locals rarely benefit economically from this booming industry. In the Atacama region of Chile, a joint Canadian-Chilean mining project is expected to make $250 million dollars per year, while each community will be compensated $9,000 to $60,000 (Ahmad, 2020). Mining rights has become a hotly debated topic, leading to conflict and protests of mining projects.

This research paper aims to analyze the impacts of lithium mining in this region and determine whether this extraction is sustainable for local communities, socially and technically. The goal of lithium mining is to promote a sustainable global future, as this lithium will be used for greener technologies, such as rechargeable batteries in hybrid electric cars. However, there is a clear contrast here. These local populations are unsustainably exploited to create a sustainable future for the rest of the world. However, this system cannot be sustainable, both technically and socially if any of its components are unsustainable, as in the case of the treatment of marginalized local communities. This paper will take a holistic approach to the sociotechnical system of lithium mining to determine the social and technical sustainability of lithium mining on local communities.

Background

To understand the complex sociotechnical system within the Lithium Triangle, one must first understand its three main actors: the transnational corporations, the provincial governments, and the local communities surrounding mining sites.

Transnational corporations, such as Argosy Minerals Ltd, from Australia, and Lithium Americas Corporation, from Canada, are companies that work within the Lithium Triangle to extract and refine lithium. As the name suggests, these corporations are foreign, mainly from more developed parts of the world. They negotiate with provincial governments and local communities to establish mines in the area (González & Snyder, 2023). However, the transnational companies exercise incredible bargaining power in these negotiations. They have the power to provide jobs and an overall increased level of industrialization in otherwise poor areas. Due to this, negotiation between transnational companies and the local communities and governments can be lopsided (Doyle, 2015).

The second actor in this network is the provincial governments. The provincial governments have control over the rights to mine and negotiate with transnational companies to allow mining projects to progress. In the lower-class regions surrounding the lithium rich salt flats, the government incentivizes mining for the economic success it can bring. To garner support from local communities, they promote the short-term benefits of lithium mining, such as employment and an overall more developed local economy. However, these provincial governments are invested in primarily industrializing to promote this economic development. This can lead them to giving favorable contracts to the transnational companies, which allow the local communities to be exploited (Ortiz, 2021).

The final of the three main actors is the local communities. These local communities bear the brunt of the impacts of mining. Firstly, mining projects can force people off ancestral land to make room for these projects. Second, water can be diverted from these communities to fuel lithium extraction. To extract lithium, huge amounts of water are necessary. This is because lithium is found in the arid regions of the desert, in briny groundwater. Briny water is then evaporated to leave behind lithium compounds. However, this process takes approximately 500,000 gallons of water for each ton of lithium. Since this is such an arid region, access to water is incredibly important. Therefore, rights to water are one of the most contentious issues in this region. This diversion of water towards mining impacts local farmers and shepherds who rely on this water for their livelihood (Ahmad, 2020). Economically, mining does slightly boost the economy. However, mining jobs are largely filled by migratory workers, who actual divert money out of the local economy (Liu & Agusdinata, 2020).

This has caused serious pushback from local communities, with varying levels of success. Locals protest ongoing mining projects and reject attempts for future projects. In Salinas

Grandes, Argentina, after companies failed to communicate relevant information on projects, locals drafted a community protocol for mining negotiation, which caused mining rights to be suspended. However, in the Jujuy province in Argentina, a similar poorly negotiation caused protest, but mining rights were not suspended (Marchegiani et al., 2020).

Sociotechnical Sustainability

To lead this analysis, a theoretical framework of sociotechnical sustainability will be employed. Moving forward, sustainability will refer to and encompass both the technical and social aspects. Technical sustainability refers to the renewable processes involved in the physical extraction of lithium from the environment. For example, technical sustainability will refer to the sustainability of water usage for lithium mining. Social sustainability will refer to the long-term stability of local communities surrounding mining projects.

Methods

To answer the research question, a comprehensive literature review was completed, focusing on the region of the Lithium Triangle. Much scholarly literature exists about lithium mining and its effects on local communities in the Lithium Triangle. This scholarly literature was compiled, with a particular focus on literature that encompasses case studies of mining projects in the Lithium Triangle. This scholarly literature of case studies highlighted the factors that affect local communities, and the different outcomes of mining and its negotiations. Then, the social and technical aspects of each case study were analyzed to determine the sociotechnical sustainability of the interaction. In doing so, a broader picture of the social impacts mining has on local communities was created.

Case Study: San Pedro de Atacama Commune

Building off the work done by Liu and Agusdinata, a closer look will be taken at the San Pedro de Atacama commune in northern Chile. The San Pedro de Atacama commune is situated at a high elevation, and experiences very little rainfall. Half of the residents of this commune belong to indigenous groups. In this area, there are two large lithium mines, operated by Sociedad Quimica y Minera, a Chilean company, and Albemarle, an American company. Mining in this region began in the 1980s but has recently quadrupled in area from 1997 to 2017.

To perform this case study, the researchers interviewed community and ethnic group leaders, and government officials. From these interviews, the researchers highlighted five impact categories: water availability, labor influx, employment and displacement, social activism, and corporate social responsibility initiatives. The researchers then analyzed each impact category in depth and concluded the sustainability of each category within the San Pedro de Atacama commune. For water availability, it was found that total water available decreased by 1.16 mm per year. Moreover, it was found that the water used for mining is about 50 times more than the water used domestically, for non-mining activities (Liu & Agusdinata, 2020). This clearly hints at unsustainable practices, both technically and socially. Mining and mining related processes are using up huge stores of water, subtracting from overall water available. This will mean that water needed by farmers and locals for day-to-day life will become ever scarcer, and the issue will only get worse, as overall water available is decreasing per year.

The next two impact zones analyzed were labor influx, and employment and displacement. In the period of 2012-2017, researchers found that there was a large influx of migratory workers entering the San Pedro de Atacama commune, 2.3 times the number of long-distance laborers who immigrated in the period of 1997-2002. Long-distance workers immigrated in 2012-2017 outnumber local laborers by 20% (Liu & Agusdinata, 2020). This is

clear evidence of a large labor influx, coinciding with the mining industry. It can be concluded that this labor influx is a result of mining, to fill the jobs that mining projects create. However, this influx of workers replaced existing local laborers. In the same time frame of 2012-2017, total labor in mining increased by 2.5 times, but the percentage of local laborers in mining industries decreased by 16%. However, the number of local laborers in most other industries increased, including agriculture and in the trade sector (Liu & Agusdinata, 2020). Advocates for lithium mining often cite employment data to support increased mining operations. However, while it is true that local employment rates often go up, local laborer employment rates in mining jobs go down. This is again evidence of unsustainability, technically and socially. The economic boost to local economies is minimal, especially as commuting laborers send capital out of the mining regions.

The last two impact zones the researcher analyzed were social activism and corporate social responsibility initiatives. They have found that from the year 2000, social activism in the San Pedro de Atacama commune increased, in response to a series of expansion permits. Also, social activism has transitioned from a local to a national scale, a notable example being a January 2019 demonstration in Santiago in which hundreds of demonstrators were repressed by police. In conjunction with social activism is corporate social responsibility initiatives, which have increased and evolved in the region since 2002. One such corporate social responsibility initiative is community sustainability reports, in which a company releases relevant economic, environmental, and social impacts of associated mining projects. Community sustainability reports began as relatively ambiguous reports in the early 2000s, but have become more advanced and detailed in the 2010s. Social initiatives, especially focused on education, such as youth entrepreneurship, have also increased and diversified in nature (Liu & Agusdinata, 2020).

The interconnected impact zones of social activism and corporate social responsibility initiatives stand in relative contrast to each other. Through corporate social responsibility initiatives, transnational companies, who for the most part transport a large portion of the wealth from lithium mining out of Chile, can give back to local communities. By fostering educational and social development initiatives, transnational corporations can help local communities prosper. However, this stands in contrast to increased social activism in this area of Chile, and on a national scale. Social activism has increased, most likely causing a similar increase in corporate social responsibility initiatives. Such a degree of social activism is unsustainable, as it demonstrates the lack of support for mining projects by the local communities. It also raises questions regarding the effectiveness of corporate social responsibility initiatives. Since corporate social initiatives develop as a response to social activism, it stands to reason that more and better initiatives would then cause a decrease in social activism. However, this is not the case, as social activism has increased in the region. This hints at the locals' view of these corporate initiatives. In the eyes of the locals, these companies are not doing enough to meet their demands, and so they continue to protest. The contraction outlined between these two impact zones demonstrates the complexity of this sociotechnical system.

Case Study: Water Rights in Chile

As mentioned above, water rights are a major concern of local communities, as they rely on it for their livelihoods. Water is a key resource because lithium-rich regions are incredibly arid. To mine lithium, companies in Chile buy water rights from the government, and extract brine. Brine is essentially incredibly saline water which contains lithium compounds. Since this brine is so salty brine is categorized as a mining resource under Chilean mining code. This has large repercussions, as water and minerals are treated very differently under Chilean law, with

different protections in place. Thus, mining companies make deals with the government to extract incredibly large amounts of brine, forgoing the wishes of the locals and more stringent water regulations (Jerez et al., 2021). This has caused dissonance in local populations, who gain money through concessions, but lose their identity, as this water is so tied to their identities. To the locals, these salt flats are a part of their ancestral lands, and so are then also a part of their heritage and identity. However, the locals' worldview is ignored, as they view this brine as water. To them, brine is water, and a sacred part of their ancestral lands. This contrasts with the argument of Lertzmen and Vredenberg, who argue that to ethically engage with indigenous populations, one must recognize their viewpoint (Lertzman & Vredenburg, 2005). Such disputes over water rights have caused litigation against mining companies. In 2019 in Chile, local communities sued to stop a mining initiative led by Wealth Mineral, a Canadian mining company. They argued in court that there was overexploitation of the Salar de Atacama region, and so killed the mining initiative (Jerez et al., 2021). Again, this hints at both technical and social unsustainability in the Lithium Triangle. Technically, the main issue is access to water. Lithium mining wastes so much water in an area where water is an incredibly precious resource. The wasted water puts at risk local communities' livelihoods. Socially, there is unsustainability in the way the local communities, local governments, and mining companies interact. The mining companies and governments preach the salvatory nature of mining, to "save" communities by bringing about an economic increase. However, this economic growth is minimal, and skewed towards companies. Such companies represent the Global North, or the wealthy countries that benefit from lithium extraction, like the US. The Global North focuses on a zero-carbon emission future, which lithium mining encourages. However, the Global North ignores the small scale, socio-environmental impacts, especially water rights (Jerez et al., 2021).

The case of water rights can be analyzed under the framework of sacrifice zones. A sacrifice zone is an area where quality of life is sacrificed for "progress." As outlined above, mining companies buy water rights in Chile to extract brine. In doing so, they often ignore the needs of local communities and do not get their consent, creating a sacrifice zone. This practice can be seen as a proliferation of the "neo-extractivist state," in which a government so desires economic growth through resource extraction that it takes advantage of local communities and environments, with or without compensation. This causes local populations to be expelled from ancestral lands in Chile, turning those lands into so-called sacrifice zones. Expulsion of the locals and ignorance of their wishes inevitably will bring about resistance from them, resisting not only the extraction system but the capitalistic root cause. The Global North is in effect sacrificing those less fortunate and less developed countries for the benefit of sustainable technologies (Kerr, 2022). Once again, this outlines a clear social unsustainability. For these local communities, they cannot prosper or thrive under such conditions. Their livelihoods and rights are being sacrificed to make way for a sustainable future. However, that is not enough. This practice of exploitation cannot and will not be effective in the long term. Under the sacrifice zone framework, the local communities will inevitably push back. In Chile, litigation and protests against lithium mining practices are abundant. The existence of such social unrest is evidence of the unsustainability of this system. To be truly sustainable, lithium mining must consider the needs and wishes of the surrounding local communities, otherwise there will be unavoidable social instability.

Case Study: Mining Negotiations in Olaroz and Salinas Grandes in Argentina

The case studies of Olaroz and Salinas Grandes offer a look into the negotiation process for mining projects, with differing outcomes. For context, in Argentina, powers regarding

resource extraction lie with the provincial governments, however there is legislation in place that allows indigenous populations the right to participate in the governance of resource extraction. To extract resources, transnational companies negotiate with provincial governments and local communities for mining rights. For more context, González and Snyder outline three main ways negotiation for mining projects occurs: non-negotiated, negotiated, and aborted extraction. Non-negotiated extraction is when a mining company makes minimal concessions to local stakeholders. In negotiated extraction, the local stakeholders can influence the process, allowing the local government and local communities to participate in regulation and governance. This type of extraction has two types: symmetrical and asymmetrical. In symmetrical negotiated extraction local stakeholders have a strong influence over how the company is allowed to operate in the region, in asymmetrical, local stakeholders have a weak influence. Aborted extraction is when the company withdraws its plans for a mining project (González & Snyder, 2023).

In Olaroz, Argentina, two mining projects are ongoing. For the proposal process, mining company representatives met with local authorities. The local authorities are made up of an elected president and committee. The company had meetings with local authorities, and outlined mining plans, including environmental and economic impacts of these mining projects. The local authorities had the power to give or withhold consent from these projects, of which only two communities of three involved in negotiations gave consent to one project. The second project was consented to by the one community that was consulted with. However, overall interactions and negotiations were not equitable according to local community members. Notably, relevant information regarding projects was not made available, or it was in highly technical language, which was hard for locals to understand. Moreover, all research was done by the companies,

which raised concerns about the legitimacy of the information. Importantly, no representatives from the provincial governments were present at meetings (Marchegiani et al., 2020).

The second case concerns Salinas Grandes, where multiple projects are proposed. Before the proposal, mining companies performed exploration activities of the area, only informing local communities partway through the exploration. However, unlike in Olaroz, local communities took a proactive approach to negotiations with mining companies. 33 local communities came together to create a community protocol to follow in negotiations, called Kachi Yupi, or Tracks in the Salt. A main point in this protocol is the need for accessible and independent information regarding projects. Also, it outlines protocols for meetings, including the need for these meetings to take place well in advance of any decisions regarding projects. It also called upon state and provincial governments to have larger participation in mining negotiations. In response to this protocol, the provincial government suspended mining rights in the Salinas Grandes region (Marchegiani et al., 2020).

The contrasts between negotiations in Olaroz and Salinas Grandes highlight the complexity of this sociotechnical system, but also again its social unsustainability. Olaroz is an example of asymmetrical negotiated extraction. In all proceedings, the companies had an unequal influence over the mining projects. They controlled the data they shared with local communities, allowing them to show information favorable to the company. This gave them an unfair advantage in negotiations, allowing them to acquire favorable agreements for mining. This is socially unsustainable as it is taking advantage of the local communities. Their needs and wishes are downplayed, and so they bear the brunt of unfair mining agreements. However, in contrast, the Salinas Grandes case study is an example of symmetrical negotiated extraction. Again, minimal relevant information was given by companies to local communities. However, the local

communities united together to exercise more equal influence over the negotiation process. Unfortunately, this is not the norm in the Lithium Triangle. Moreover, it favors organized communities, rather than disorganized. Again, such negotiations and methods of extraction are socially unsustainable. Poorer, less organized communities are easily exploited by million-dollar transnational corporations. Another major factor is the lack of state or provincial involvement in proceedings. The government is made of and for the people, and so should have their interests at heart. By not participating in negotiations, it further allows local communities to be unsustainably exploited by large companies.

Conclusion

As is clear, the current methods of lithium extraction are socio-technically unsustainable for the local communities that surround mining projects. Provincial governments allow favorable mining agreements for transnational companies, often ignoring community wishes. Transnational corporations are allowed to exploit local communities through unsymmetrical negotiations with them. In doing so, the wishes of local communities are sacrificed at the cost of industrialization. However, the benefits of industrialization are minimal for the local communities that bear the brunt of the costs. Moreover, conflict over water rights highlights the technical unsustainability of lithium extraction. So much water is used for lithium extraction that it affects the livelihoods of locals. This necessitates protests by the local communities to fight for their needs. At its heart, there is a contradiction in the sustainable future lithium mining promises. Lithium mining promises rechargeable batteries for anything from electric cars to airplanes to laptops. However, the local communities are exploited unsustainably to achieve this future. To reduce the exploitation of locals, there should be a much larger governmental influence on mining projects (Ortiz, 2021). Much more rigorous legislation and protocols should be in place to protect the

wishes and values of local communities. In the future, a policy analysis should be completed to determine effective or ineffective legislation to protect such marginalized communities. Overall, this research outlines the pattern of exploitation surrounding lithium extraction in South America. However, lithium is by far not the only raw material being mined. In China, rare earth metal mining has similar effects on local populations. Through this research, hopefully more negatively affected local communities around resource extraction can be identified and protected, to ensure a more equitable and sustainable future for everyone.

Works Cited

Ahmad, S. (2020). The Lithium Triangle: Where Chile Argentina, and Bolivia Meet. *Harvard International Review*, *41*(1), 51–53.

Annual CO2 emissions worldwide 1940-2021. (n.d.). Statista. Retrieved February 27, 2023, from https://www.statista.com/statistics/276629/global-co2-emissions/

Doyle, C. (2015). Lithium and Rare Earth Elements: The Dirty Business of Clean Energy. *Chicago-Kent Journal of Environmental and Energy Law*, *5*, 1–22.

González, L. I., & Snyder, R. (2023). Modes of Extraction in Latin America's Lithium Triangle: Explaining Negotiated, Unnegotiated, and Aborted Mining Projects. *Latin American Politics and Society*, *65*(1), 47–73. https://doi.org/10.1017/lap.2022.32

Jerez, B., Garcés, I., & Torres, R. (2021). Lithium extractivism and water injustices in the Salar de Atacama, Chile: The colonial shadow of green electromobility. *Political Geography*, *87*, 102382. https://doi.org/10.1016/j.polgeo.2021.102382

Kerr, L. (2022). Expelled and Sacrificed: Exploring Lithium and Resistance. *Political Science Undergraduate Review*, *7*(2), Article 2. https://doi.org/10.29173/psur291

Lertzman, D. A., & Vredenburg, H. (2005). Indigenous Peoples, Resource Extraction and Sustainable Development: An Ethical Approach. *Journal of Business Ethics*, *56*(3), 239–254. https://doi.org/10.1007/s10551-004-3528-8

Lithium demand worldwide by application 2020-2030. (n.d.). Statista. Retrieved February 27, 2023, from https://www.statista.com/statistics/1220158/global-lithium-demand-volume-by-application/

Liu, W., & Agusdinata, D. B. (2020). Interdependencies of lithium mining and communities sustainability in Salar de Atacama, Chile. *Journal of Cleaner Production*, *260*, 120838. https://doi.org/10.1016/j.jclepro.2020.120838

Marchegiani, P., Morgera, E., & Parks, L. (2020). Indigenous peoples' rights to natural resources in Argentina: The challenges of impact assessment, consent and fair and equitable benefit-sharing in cases of lithium mining. *The International Journal of Human Rights*, *24*(2–3), 224–240. https://doi.org/10.1080/13642987.2019.1677617

Ortiz, E. M. (2021). *The Role of the State and the Environmental Impacts of Lithium Mining in Jujuy, Argentina* [M.A., University of California, Los Angeles]. https://www.proquest.com/docview/2583000997/abstract/E05CAF7924DF43EDPQ/1